Regional Operational Plan SF.1J.2015.01

Coho Salmon Coded Wire Tagging and Escapement at Cowee Creek, 2015–2017

by

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and

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March 2015

Alaska Department of Fish and Game   **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat or long
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations

alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	$(F, t, \chi^2, etc.)$
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	E
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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SIGNATURE PAGE

Project Title: Coho salmon coded wire tagging and escapement at Cowee Creek, 2015-2017

Project leader(s): Kercia Schroeder, Fishery Biologist II

Division, Region, and Area: Sport Fish, Region I, Juneau

Project Nomenclature: F-10-30+*N1507*, F-10-31+*NEW*, F-10-32+*NEW*

Period Covered: April 15, 2015—October 31, 2017

Field Dates:
April 15, 2015—June 15, 2015
August 1, 2015—October 31, 2015
April 15, 2016—June 15, 2016
August 1, 2016—October 31, 2016
August 1, 2017—October 31, 2017

Plan Type: Category II

Approval
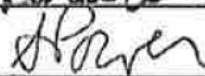
Title	Name	Signature	Date
Project Leader	Kercia Schroeder	*[signature]*	3/4/15
Biometrician	Sarah Power	*[signature]*	3-4-15
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ABSTRACT

A coho salmon (*Oncorhynchus kisutch*) stock assessment project consisting of a series of 2-event mark-recapture experiments will be conducted at Cowee Creek, which is located north of Juneau and accessible from the road system. In spring 2015 and 2016, coho salmon smolt emigrating from Cowee Creek will be captured using a combination of minnow traps and a spill trap; smolt ≥75 mm FL will be marked with coded wire tags and adipose fin clips. Marked fish harvested in marine sport and commercial fisheries (in 2015-2017) will be sampled by Alaska Department of Fish and Game port and creel sampling programs, which along with the estimation of the tagging rate, will provide a means for estimating marine harvest of coho that emigrated from Cowee Creek in 2014-2016. In the fall of 2015-2017, the inriver run will be sampled to estimate the adult escapement, the smolt tagging rate, and the number of coho salmon smolt that emigrated from Cowee Creek in 2014-2016, respectively. All captured adults will be sampled for age, sex, and length data. Information resulting from this mark-recapture study will allow managers to determine the extent of marine harvest related to this important roadside fishery, in addition to providing the basis for a more robust stock assessment.

Key words: Cowee Creek, Juneau roadside fishery, Southeast Alaska, coho salmon, stock assessment, mark-recapture, coded wire tag, marine survival, escapement, smolt production, marine harvest.

PURPOSE

The main purpose of this project is to estimate marine harvest and determine where, when, and by what gear type adult coho salmon (*Oncorhynchus kisutch*) from Cowee Creek are intercepted in marine fisheries. Cowee Creek, located on the Juneau road system, is believed to have one of the largest runs of coho salmon within this area, and is one of the most heavily fished streams in the Juneau roadside fishery. Currently, only limited information exists on the Cowee Creek coho population. Emigrating juvenile coho salmon will be tagged with coded wire tags (CWTs); tagged adults will be recovered in marine and inriver sampling programs to estimate abundance and harvest, and to assess timing and distribution of marine harvest. This information will allow managers to determine the extent of marine harvest related to this important roadside fishery, in addition to providing the basis for a more robust stock assessment, including estimates of recruitment, marine survival, run-timing, size, and other ancillary data.

BACKGROUND

The core mission of the Alaska Department of Fish and Game, Division of Sport Fish (ADF&G-SF) is to protect and improve the state's recreational fisheries resources (ADF&G 2015b). A number of goals and supporting objectives have been identified to ensure the mission is achieved. To successfully manage these resources, it is important for managers to: 1) identify data needs or gaps that exist; 2) prioritize stock assessment and research projects based on existing information needs; and 3) determine if any management concerns exist, based on data gathered through ADF&G-SF projects (ADF&G 2015b). Occasionally, concerns raised by the public or proposals submitted through the Board of Fisheries process may alert the attention of managers to issues not otherwise prioritized or considered. This may be especially true if potentially significant shifts in sport or commercial harvest patterns and effort occur.

Coho salmon are an important resource to numerous sport, commercial, and subsistence users in Southeast Alaska (SEAK) (Elliott and Kuntz 1988; Schmidt 1988; Halupka et al. 2000; Shaul et al. 2011; McCurdy 2012). The principle management objective, acted on jointly by the ADF&G-SF and ADF&G Division of Commercial Fisheries (ADF&G-CF), for coho salmon in SEAK fisheries is to achieve maximum sustained yield (MSY) from wild stocks. A secondary management objective, that may have varying significance for specific coho stocks, is to maintain long-term commercial gear-type allocations that were established by the Alaska Board

of Fisheries in 1989. In the early 1980s, ADF&G implemented an improved stock assessment program to better understand and manage coho salmon stocks; new assessment projects were implemented for indicator stocks, which formed the basis for improved management of the species (Shaul et al. 2011). Despite the additional effort, stock-specific information is not available for over 90% of the coho salmon stocks in SEAK. Managing coho populations across SEAK is further clouded by the fact that the majority of commercial harvest occurs in temporally and geographically dispersed mixed stock fisheries where individual coho stocks intermingle (Shaul et al. 2011). The fact that coho have an extensive distribution in SEAK and return to fresh water during times of inclement weather and high stream flow further contribute to the complexity and cost of obtaining data once adults return to their natal streams. As a result, most data are derived from a small and limited subset of stocks throughout SEAK. Lack of sufficient information is the most pervasive risk factor threatening sustainable management of coho salmon stocks in the region (Halupka et al. 2000).

Coho salmon typically return to the marine waters of SEAK in July and August and enter fresh water in September and October. The direction of the return migration generally moves from northwest to southeast along the coast; however, relatively little is known about the migration routes used by specific coho salmon stocks (Schmidt 1988; Halupka et al. 2000). Commercial fisheries targeting other salmonid species often harvest a substantial incidental catch of coho salmon, which makes run timing an important biological trait that influences vulnerability. In general, stocks that pass through the most fisheries during their spawning migrations experience the highest exploitation rates. Stocks located in Lynn Canal, stocks in the Taku River region, and stocks in southern Southeast Alaska have the highest exploitation rates; stocks on the outer coast generally have the lowest exploitation rates (Halupka et al. 2000). Small stocks are particularly vulnerable to high exploitation rates, which may or may not be sustainable (Hilborn 1985; Elliott and Kuntz 1988; Halupka et al. 2000). Considering the above, those coho stocks associated with small or moderately-sized systems and located in inside waters of SEAK may be particularly vulnerable to unsustainable exploitation.

Recreational fisheries occur in both fresh and saltwater areas and have constituted an increasing component of the total coho salmon catch in recent years (Shaul et al. 2011). Based on ADF&G Statewide Harvest Survey (SWHS) results, one of the largest runs of coho salmon and one of the most heavily fished streams in the Juneau roadside fishery is Cowee Creek, located at the northern extent of the Juneau road system (ADF&G 2015a; Figure 1; Appendix A). There is very little additional information available on the Cowee Creek coho population; fish populations in this system have never been assessed in detail, either through juvenile fish studies or adult escapement surveys. The semi-glacial water condition in the Cowee Creek mainstem is one of the primary reasons for the lack of information on fish populations in the system (Bethers et al. 1995), at least with respect to visual counts of adult coho salmon obtained by foot or air.

In 2013, ADF&G-SF initiated a multi-year coded wire tagging stock assessment project on Cowee Creek; this 2015 operational plan describes work that will be conducted during the remainder of the project (2015-2017). The primary focus of this project is to gain information about where and when adult coho salmon, originating in Cowee Creek, are harvested in marine fisheries. This will be realized by tagging juvenile coho salmon emigrating from Cowee Creek, followed by the recovery of returning adults intercepted in marine waters and in the freshwaters of Cowee Creek. Tags recovered in marine sport and commercial fisheries will yield information on where (statistical area, district, etc.), when (statistical week), and how (type of fishery) coho

smolt tagged in 2015 and 2016 were harvested during 2016 and 2017. This information will be useful to managers who are responsible for protecting this important and productive Juneau roadside fishery. Funding for the work outlined in this operational plan is provided through the Dingell-Johnson (DJ) Fund with a 25% match provided by the Fish and Game Fund.

Description of Project Area

Cowee Creek is located approximately 64 km north of Juneau in the temperate coastal rainforest of SEAK (Figure 1). Cowee Creek is a popular sport fishing location due to its productive fisheries, road system access, and the presence of a trail that allows public access to fishing holes in the lower portion of the watershed (Figure 2). Cowee Creek has populations of coho, pink (*O. gorbuscha*), and chum salmon (*O. keta*), Dolly Varden (*Salvelinus malma*), and cutthroat trout (*O. clarkii*), and is reported to have small runs of spring and fall steelhead (*O. mykiss*) (Bethers et al. 1995). The Cowee Creek watershed has a drainage area of approximately 119 km^2 and empties into salt water at the south end of Berners Bay. The watershed is bordered by snow and glacier covered mountains and includes numerous tributary streams, of which Davies Creek, South Fork, and Canyon Creek are the largest (Figure 2). Both Cowee and Davies creeks have hanging glaciers that drain into their respective valleys (USFS 2009) that result in semi-glacial stream conditions from spring through fall (Bethers et al. 1995). Cowee Creek is believed to contain the largest amount of low gradient, floodplain stream habitat on the Juneau road system (CBJ 2015), and these habitats are often considered the most productive for salmon.

Nearly 88% of the land within the watershed boundary is owned and managed by the United States Forest Service (USFS), most of which is designated as the Héen Latinee Experimental Forest (USFS 2009). Other landowners within the watershed include: 1) the State of Alaska (including Point Bridget State Park); 2) Goldbelt, Incorporated; and 3) private owners. Land owned by the USFS is primarily in the upper portion of the watershed, while other entities own land in the lower portion of the watershed (Figure 3).

OBJECTIVES

1. Estimate the number of coho salmon smolt (≥75 mm FL) leaving Cowee Creek in 2015 and 2016, such that the estimated number is within ±30% of the true value 80% of the time.
2. Estimate the age composition of coho salmon smolt (≥75 mm FL) captured in 2015 and 2016, such that all age classes are estimated within ±15 percentage points of their true values 95% of the time.
   a. Estimate the proportion of small coho salmon smolt (75–85 mm FL) that are freshwater age 1 such that the estimate is within ±15 percentage points of the true value 95% of the time based on an a proportion ≥ 0.85.
   b. Estimate the proportion of large coho salmon smolt (>85 mm FL) that are freshwater age 1 such that the estimate is within ±15 percentage points of the true value 95% of the time based on a proportion of 0.50.
3. Estimate the marine harvest in sampled salmon fisheries in 2016 and 2017 of adult coho salmon that originated from Cowee Creek via recovery of CWTs applied in 2015 and 2016, respectively, such that the half-width of the calculated 95% confidence interval is 35% of the estimate.
4. Estimate the escapement of adult coho salmon in 2015 and 2016, between August 1 and October 31, such that the estimate is within ±45% of the true value 80% of the time.
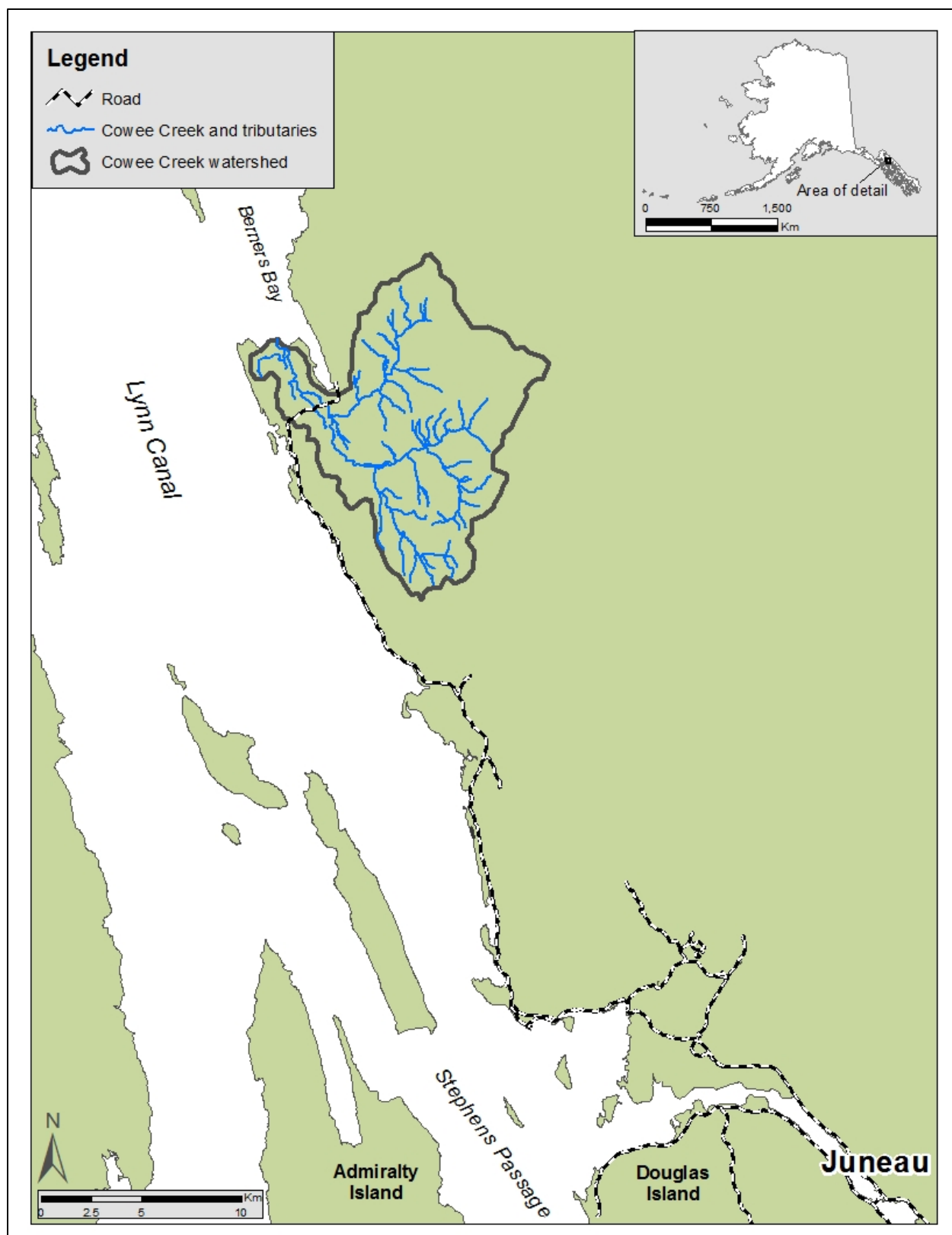
Figure 1.–Location of Cowee Creek watershed in Southeast Alaska.
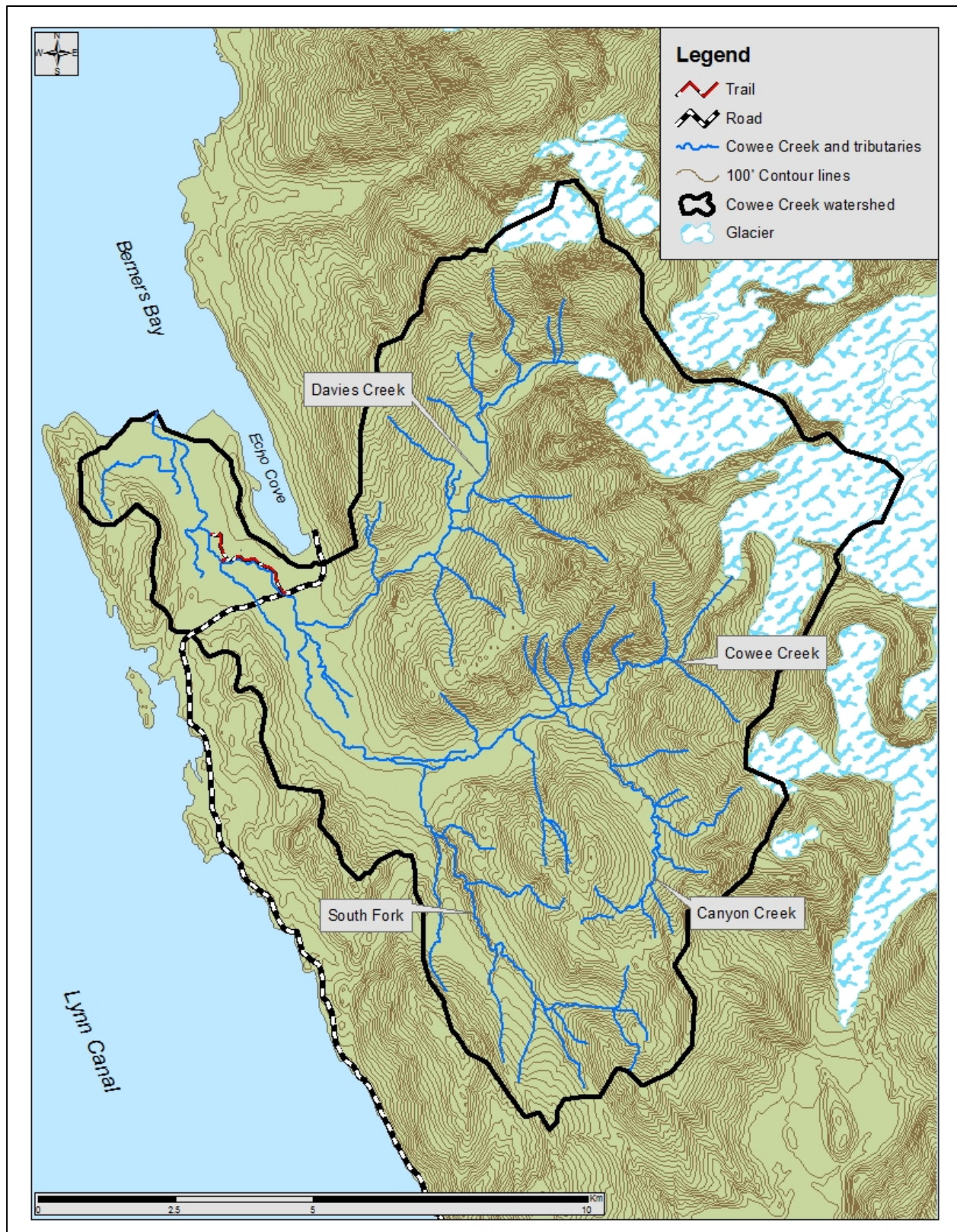
Figure 2.–Map identifying Cowee Creek and significant tributaries in Cowee Creek watershed, Southeast Alaska.
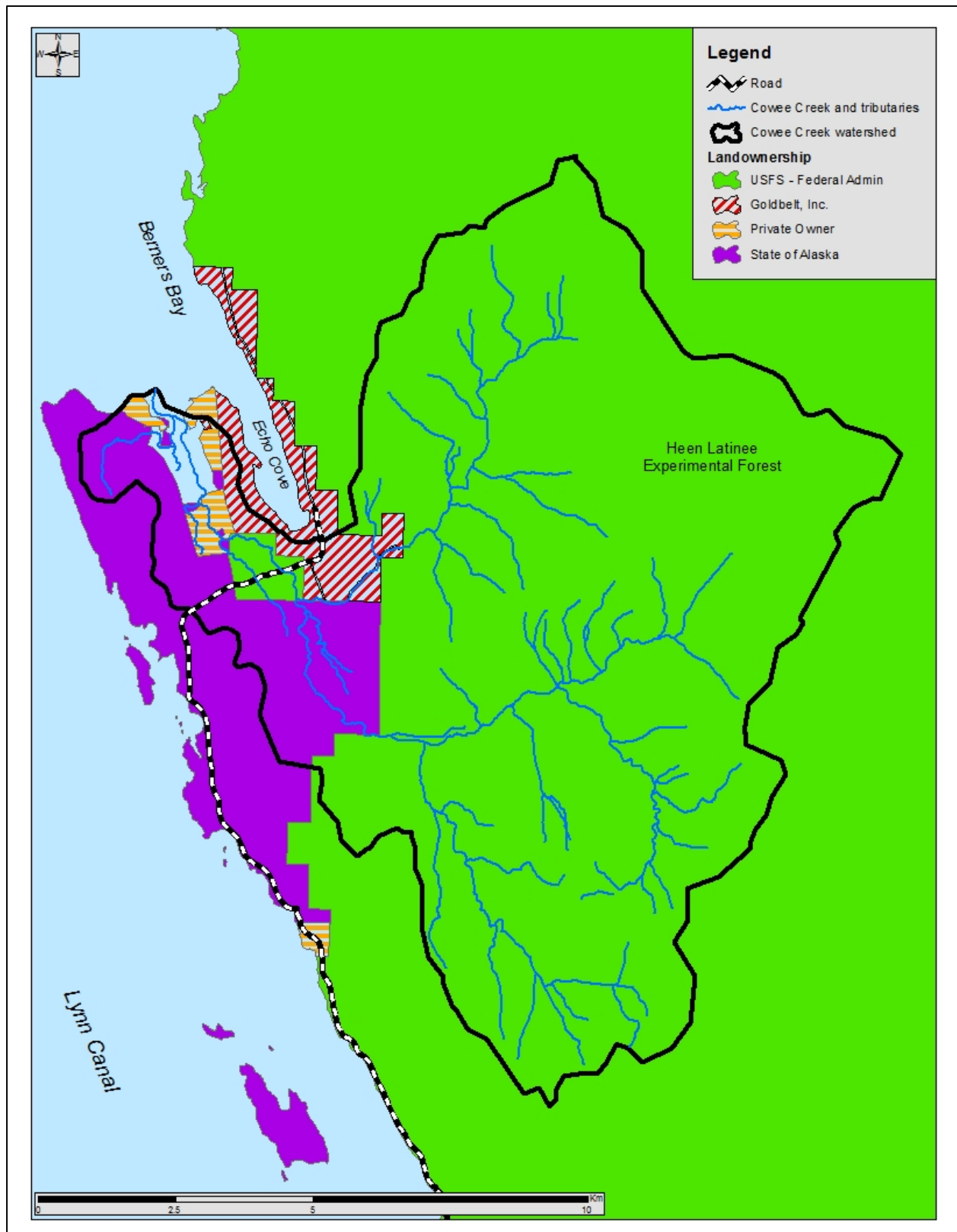
Figure 3.–Map identifying landownership in Cowee Creek watershed, Southeast Alaska.

SECONDARY OBJECTIVES

This project will address the following secondary objectives:

1. Estimate the mean length of coho salmon smolt (≥75 mm FL) in 2015 and 2016.

2. Estimate the mean weight of coho salmon smolt (≥75 mm FL) in 2015 and 2016.

3. Test the hypothesis that smaller coho salmon smolt (75–85 mm FL) survive at the same rate as larger smolt (>85 mm).

4. Determine the freshwater age of all adult coho salmon with readable scales sampled in Cowee Creek in 2015-2017.

5. Determine the length and gender of all adult coho salmon sampled in Cowee Creek in 2015-2017.

6. Record numbers of coho smolt and adults captured–by location–with the use of handheld Global Positioning System (GPS) units for each trap or gear type used.

7. Measure stream water conditions at the Cowee Creek bridge; water temperature will be recorded to the nearest 0.5°C and stream water level will be measured to the nearest 10th of a foot, during each day of operations.

8. Collect genetic samples throughout the adult run.

METHODS

STUDY DESIGN AND SAMPLE SIZES

Smolt Sampling

Smolt Abundance

A 2-event closed population mark-recapture experiment will be used to estimate the abundance of coho salmon smolt that emigrate from Cowee Creek in 2015 and 2016. Smolt will be tagged both years, in the spring, with CWTs and marked with adipose fin clips as part of Event 1 of the 2-event experiment. As part of Event 2, returning adult coho salmon will be inspected inriver for a missing adipose fin in 2016 and 2017, respectively.

A minimum of a 2-person crew will be dedicated to capturing, tagging, and releasing juvenile coho salmon with CWTs. These activities will occur daily between approximately April 20 and June 12, in 2015 and 2016. Additional crew members will be used as available.

Emigrating juvenile coho salmon will be captured primarily in the lower portion of Cowee Creek watershed (Figure 4), using a combination of minnow traps and a spill trap. Each day, a 2–3 person crew will be responsible for performing all trapping and tagging activities. Approximately 25–30 baited minnow traps will be operated in the mainstem and tributaries located in close proximity to the road system. Smolt trapping will not take place in tidally influenced reaches to avoid the additional stress that could occur in transitional habitats. Trapping effort may be adjusted based on additional staff availability, weather and water conditions, or smolt timing, distribution, and abundance patterns. In addition to the use of minnow traps, a spill trap will be installed near the outlet of a beaver pond complex where approximately 75% of all coho smolt tagged in 2013 and 2014 were captured (Figure 4).
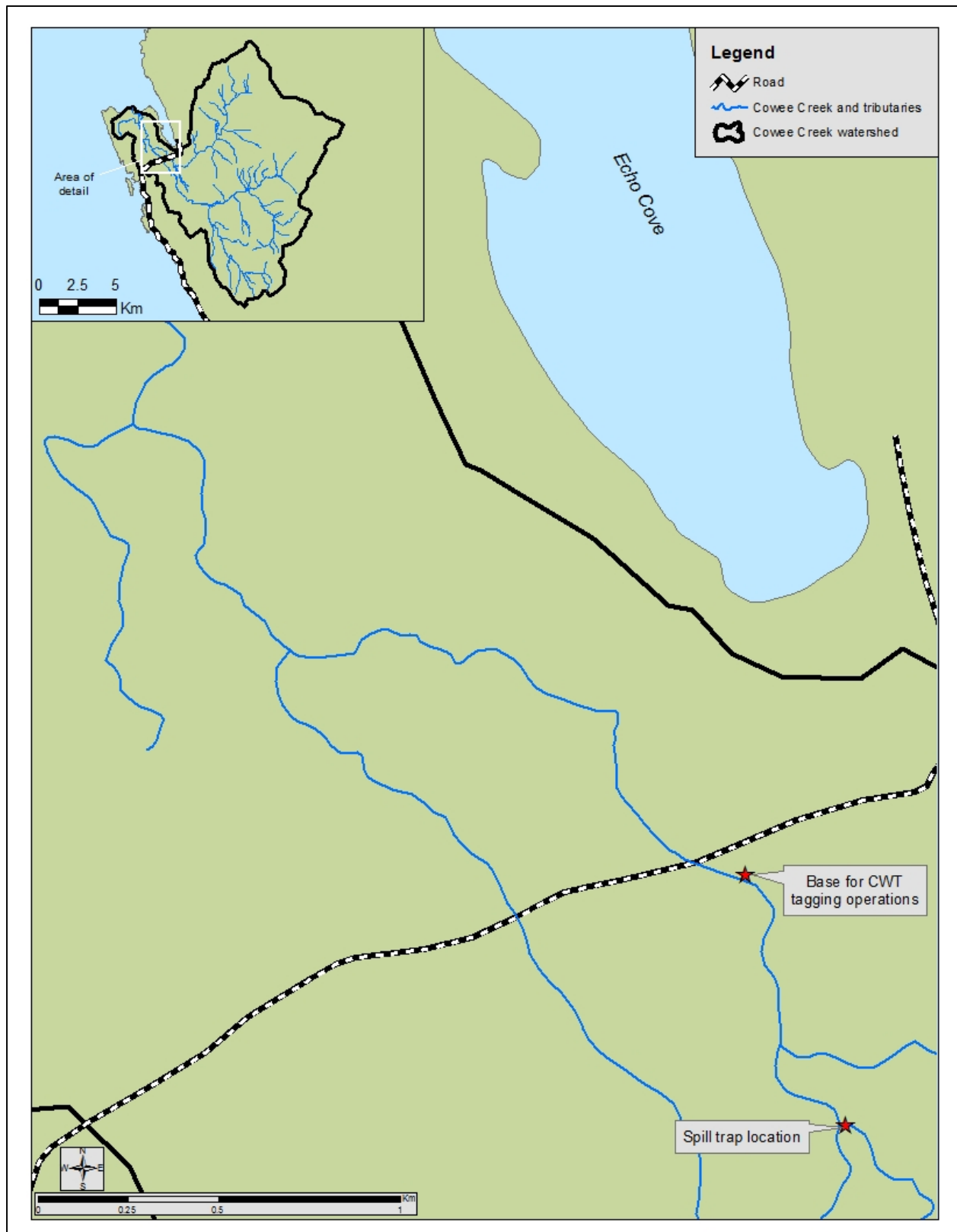
Figure 4.–Map displaying the lower portion of Cowee Creek watershed where juvenile coho salmon capture, sampling, and tagging will occur in 2015 and 2016, Southeast Alaska.

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Methods that will be used for operation and maintenance of minnow and spill traps will closely follow those described in Magnus et al. (2006). All healthy coho smolt ≥75 mm FL captured each day will be transported by foot to a central location on the mainstem, near the bridge, for sampling and tagging (Figure 4). Fish will be transported in buckets using aerators to help maintain adequate oxygen levels, and water will be added as needed to maintain a near constant temperature similar to stream temperatures. Juvenile coho salmon that are ≥75 mm FL will be tranquilized with a buffered MS 222 solution, will have their adipose fin removed, and will be injected with a CWT. Each CWT will be formed and inserted in the smolt by using a Mark IV tagging machine that cuts a 1.1 mm section of wire from a spool stamped with a unique numeric code. Each spring, 2 different spools of wire will be used to tag 2 size classes of coho salmon smolt: those 75–85 mm FL (small), and those >85 mm FL (large) (Table 1).

Table 1.–Coded wire tag codes that will be used for tagging small and large juvenile coho salmon on Cowee Creek, 2015 and 2016.

Smolt size class	Spool Size	Tag code	Year
Small (75-85 mm)	2.5K	TBD	2015
Large (> 85 mm)	10.0K	TBD	2015
TBD[a]	2.5K	TBD	2015
Small (75-85 mm)	2.5K	TBD	2016
Large (> 85 mm)	10.0K	TBD	2016
TBD[a]	2.5K	TBD	2016

[a] Additional tag codes will be available for use to tag more smolt of the above size classes if need be.

Prior to release, all tagged fish will recover for 24 hours in a holding pen and will be checked for tag retention and post-tagging mortality to ensure a ≥98% retention rate. The subsample of tagged fish to check for tag retention will consist of 100 fish if the total number of tagged fish is ≥100; otherwise, every tagged fish will be examined for tag retention. Following these actions, all fish will be released in pocket waters of the mainstem near the sampling and tagging location. Fish will be released in a manner so that predators do not become habituated to release events.

When checking traps, recaptured fish will be identified by a missing adipose fin and will be checked for tag retention using methods described in Magnus et al. (2006). Observers will be sure to test arms and clothing carefully before conducting tag retention to ensure the detector is reacting to a CWT and not giving a false positive due to magnetic interference from another piece of metal. Fish that register as a negative will be retagged and will be counted separately, as they have already been counted as a tagged fish once. Retagged fish will recover for 24 hours in a holding pen and will be checked again for tag retention. Notes about the presence or absence of a CWT in recaptured smolt will be taken in order to determine the long-term retention rate of CWTs in the study.

Event 2 of the mark-recapture experiment will occur in 2016 and 2017, when adult coho salmon returning to Cowee Creek will be sampled and inspected for missing adipose fins. The marked fraction (fish missing adipose fins) of coho salmon captured will be used to estimate smolt abundance in 2015 and 2016 and marine harvest in 2016 and 2017.

Model Assumptions for Estimation of Smolt Abundance

This 2-event closed population mark-recapture experiment is designed so that a Petersen-type estimator may be used to estimate smolt abundance. For the estimate of abundance to be unbiased, certain assumptions must be met (Seber 1982). These assumptions, expressed in the circumstances of this study, along with their respective design considerations and test procedures, are:

Assumption I: There is no recruitment to the population between years.

Considering the life histories of coho salmon, there should be no recruitment between sampling events. Because almost all surviving smolt return to their natal stream as adults to spawn, there will be no meaningful recruitment added to the population while they are at sea (i.e., low incidence of straying).

Assumption II: There is no trap-induced behavior, including mortality.

There is no explicit test for this assumption because the behavior of unhandled fish cannot be observed. Trap-induced behavior is unlikely because different sampling gears will be used to capture smolt and adults. Results from other studies (Elliott and Sterritt 1990; Vincent-Lang 1993) indicate that clipping adipose fins and implanting CWTs does not affect the mortality of tagged salmon smolts.

Assumption III: Tagged fish will not lose their marks between sampling events and all marks are recognizable.

The use of properly applied adipose fin clips will ensure that marks are not lost and that all marked fish are recognizable during second event sampling. Adipose fins will not regenerate like other fins if excised at the base. Naturally missing adipose fins on wild stocks of coho salmon are very rare (Magnus et al. 2006).

Assumption IV: One of the following 3 sets of conditions on mortality and sampling will be met:
- S1. All fish have an equal probability of being captured and marked during the first event; or
- S2. All fish have the same probability of surviving between events whether marked or unmarked and across all tagging groups and complete mixing of marked and unmarked fish occurs prior to the second event; or,
- S3. All fish have the same probability of surviving between events whether marked or unmarked and across all tagging groups and all fish have an equal probability of being captured and inspected for marks during the second event.

Assumption V: All fish marked as juveniles are smolt emigrating to sea during the same year they were marked and will not return to another stream.

One might have support that this assumption has been violated if a tag code comes back a year later than expected, or if a tag code is recovered escaping to a different system. If there are fish that do not smolt in a given tagging year, or return to a different system, then it may appear that there is a higher marked-to-unmarked ratio. If the smaller juveniles are less likely to smolt, it will appear that smaller fish survived at a lower rate.

As water conditions allow, minnow traps and the spill trap will be operated continuously, 7 days a week during the 2015 and 2016 smolt emigration. In 2016 and 2017, adult coho salmon

immigrations will be sampled throughout the Cowee Creek watershed, 5 days a week, as water conditions allow.

It is noted that migration during both events may vary from day to day due to short-term changes in water conditions and fish behavior. Non-constant sampling and daily variations may reduce equal probabilities of capture throughout migrations, although the vast majority of fish will be eligible for capture. However, S2 of assumption IV is expected to be met. Recall that this assumption does not rely on equal probability of capture. Due to the extended time period between the marking and recovery events and the difference in behavior of salmon between these events, it is likely that complete mixing of marked and unmarked fish will effectively occur prior to the adult recovery events.

A contingency table analysis (Agresti 2007) will be conducted to test the null hypothesis that the probability of an adult missing an adipose fin is independent of when the fish was inspected for marks during the second event. Failure to reject the null hypothesis will indicate that S1 and/or S2 of assumption IV are satisfied.

Coho salmon smolt likely represent at least 2 age groups and cover a range of sizes. In the Taku River, there has been size-selective sampling during the first event and size-differential mortality rates detected for coho salmon emigrating from the Taku River (Jones et al. 2006), resulting in failure of all 3 sets of conditions.

Equal survival between the coho smolt tagging groups (2 sizes) will be evaluated using contingency table analysis (Agresti 2007) to test for lack of independence between tagging group and probability of recovery during adult sampling (Secondary Objective 3). If no lack of independence between tagging group and adult tag recovery is detected, at least S2 is satisfied and Chapman's (1951) modification to the Petersen estimator will be used to estimate abundance after pooling the tag codes. If lack of independence is detected between adult tag recovery rate and tagging group, then equal probability of capture during the tagging event will need to be evaluated. The weighted variant of Chapman's modification to the Petersen estimator (equation 3 below) must be calculated in order to estimate the ratio of the catchability coefficient for larger to smaller smolt A (equation 5 below) and the sampling variance of the ratio. If the estimate of A is not significantly different from 1.0, Chapman's (1951) formula will be used to estimate abundance as noted above. Otherwise, the modified estimator (equation 3) will be used to provide an unbiased estimate (see Data Analysis; Appendix C1). Past use of this estimator on the Taku River has increased the coefficient of variation of the estimate modestly (about 2.5 percentage points) (Williams et al. 2013b).

Assuming 250,000 smolt emigrate from Cowee Creek in 2015 and 2016, and 7,000 smolt are released with coded wire tags, using the methods of Robson and Regier (1964), a minimum of 618 adult (ocean age 1) coho salmon will need to be inspected in the Cowee Creek escapement in 2016 and 2017 to satisfy the precision criterion in Objective 1.

Smolt Age Composition

Based on an expected catch of about 7,000 coho salmon smolt, scale samples will be taken from every 25th coho salmon smolt to achieve a systematic sample of 280. Assuming scales from 20% of the fish sampled are unreadable, a minimum sample of 28 small smolt (75–85 mm) and 55 large smolt (>85 mm) will be necessary to meet the precision criteria in Objectives 2a and 2b,

respectively (Cochran 1977). The precision criteria for Objectives 2a and 2b are necessary to minimize the contribution of the variances of $\hat{\phi}_1$ and $\hat{\phi}_2$ to the variance of A (see equation 5).

During the 2014 smolt sampling effort in Cowee Creek, approximately 19% of the smolt tagged were small and 81% were large. If similar proportions are realized in 2015, approximately 53 small smolt and 226 large smolt will be sampled. The overall sample of 280 will be more than sufficient to meet the precision criterion for Objective 2.

Smolt Mean Length

No precision criteria were given for Secondary Objectives 1 and 2 relating to mean length and weight of coho smolt, as these data are considered ancillary. The sample size for estimating ages should be large enough to get a reasonably precise estimate on mean length and weight. Weights and lengths will be recorded for every 25th coho salmon smolt sampled (i.e., every smolt that scales are taken from).

Adult Sampling

Adult Marine Harvest

After losses due to natural and harvest mortality in the marine environment, virtually all coho salmon smolt tagged in 2015 and 2016 are expected to return to the Cowee Creek watershed to spawn in 2016 and 2017, respectively. Some returning adults will be harvested in marine sport and commercial fisheries in 2016 and 2017, which are sampled by ADF&G port and creel sampling programs. Heads will be collected from fish carrying CWTs, as identified by a missing adipose fin. The CWTs will be decoded by the ADF&G-CF Mark, Tag, and Age Laboratory (Tag Lab). Recovery of Cowee Creek CWTs intercepted in marine fisheries will provide important information to managers about where and when Cowee Creek coho salmon are being harvested. Additionally, with the inriver adult work, a marked-to-unmarked ratio will be estimated, which will allow for expanding the number of tags recovered in fisheries to the number of Cowee Creek coho harvested in those fisheries. Additionally, an escapement estimate in 2016 and 2017 will allow an exploitation rate estimate to be developed. See appendix B1 for the first year of marine harvest information from Cowee Creek coho tagged in 2013.

The first year of available harvest data was from smolt tagged in 2013 that were harvested in 2014. In the first year of this project 2,259 smolt were tagged (0.3% of estimated smolt abundance), which was approximately a third of the 7,058 smolt tagged the following year. In 2014, Cowee Creek coho tags showed up in both troll and drift gillnet fisheries, but not in seine or sport fisheries. With the number of released tags expected to increase 3-fold in 2015, it may be possible to estimate harvest in seine and sport fisheries through tags recovered in 2015. Based on comparisons with the Taku, the seine fishery is anticipated to harvest less fish than all other marine fisheries, which would make it more difficult to estimate.

The 2014 total harvest relative precision was 61% based on a 95% CI (estimated harvest 15,587; SE 4,814; 4,814/15,587*1.96 = 61%). Harvest was only estimated for the troll and drift gillnet fishery as no tags were found in the seine or sport fisheries. With a 3-fold increase of released tags, it is expected that under similar conditions, relative precision will become 35% for the troll and drift gillnet fisheries alone. Based on having recovered no tags in the seine and sport fisheries, there will be no attempt to speculate on what the relative precision might be produced

if a tag shows up in those fisheries. The following calculations are based on the fisheries that tags did show up in.

To meet the precision criterion in Primary Objective 3 (95% relative precision (RP) = ±35%), 3% of the coho salmon smolt (or approximately 7,000) need to be tagged in 2015 and 2016, according to procedures in Bernard et al. (1998). This is based on inspecting about 20% of the anticipated harvest in certain commercial fisheries we have estimates for (Anne Reynolds , FisheryBiologist IV, ADF&G-CF, Douglas, personal communication).

Assuming 250,000 coho salmon smolt emigrate and 7,000 of them are tagged in both 2015 and 2016, 36 random fishery recoveries of CWTs are anticipated during both 2016 and 2017. This number was calculated assuming, with all else being equal, that there will be three times as many tags available compared to 2014. Methodology in Bernard et al. (1998) was used to estimate the chance of missing harvest in fisheries. In the commercial troll fishery, the anticipated probability of recovering at least one CWT in all troll strata is 0.77 and the anticipated troll fishery harvest would be 37% of the returning run if run sizes remain similar. The anticipated probability of recovering at least one CWT in all drift gillnet strata is 0.57 and the anticipated drift gillnet fishery harvest is 24% of the total returning run if run sizes remain similar.

In 2016 and 2017, adult coho salmon returning to Cowee Creek will be sampled and inspected for missing adipose fins between the beginning of August and the end of October. The marked fraction (fish missing adipose fins) of coho salmon captured will be used to estimate smolt abundance in 2015 and 2016 and the harvest in the marine environment during 2016 and 2017, respectively. See the "Smolt Abundance" section earlier in this methods section (Pages 7-11).

Adult Escapement

A mark-recapture experiment will be conducted between early August and the end of October, for the next 3 years (2015-2017), when adult coho salmon returning to Cowee Creek will be sampled and inspected for missing adipose fins. Escapement of adult coho salmon in Cowee Creek will be estimated using a Petersen-type mark-recapture model (Seber 1982). During each fall adult coho salmon returning to Cowee Creek will be sampled and inspected for missing adipose fins to estimate the marked-unmarked ratio from the smolt marking event that occurred the spring of the previous year. Each year, the marked-unmarked ratio of returning adults will be used to estimate smolt abundance for the previous year. It should be noted that during adult sampling in 2014, there were no observations of tagged coho jacks that might have returned. However, assuming that jacks make up a small percentage of the run, and further understanding that year-to-year jack percentage will not vary widely, any jacks identified by aging or inference by size will be included in that year's adult mark-recapture. This limitation is accepted with the idea that the resulting bias should be low.

A minimum of a 2-person crew will be dedicated to capturing and sampling adult coho salmon; additional crew members will be used as available. Adult salmon will be captured weekly in Cowee Creek using a beach seine (15-m long x 4.5-m deep, with 3.8-cm stretch mesh), tangle net (12.5-m long x 2.5-m deep, with 7.5-cm stretch mesh), dip nets, and hook-and-line (i.e., sport fishing) gear. Care will be taken not to injure any fish during capture and sampling; extra care will be taken in handling fish captured in the lower river due to sensitivity to handling stress observed in transition zones in other systems.

Each adult coho salmon captured will be sampled using methods similar to other ADF&G-SF salmon mark-recapture stock assessment projects in SEAK (Chapell and Elliott 2013; Jaecks et al. 2013; Johnson 2013; Williams et al. 2013a). Captured coho will be inspected for adipose fin clips (indicating they were CWT-tagged as a juvenile), presence of a T-bar anchor tag (indicating they were sampled during the first adult sampling event), and operculum punches (indicating they have already been previously sampled during the first or second adult sampling event). After inspection, all adult coho salmon that have not been previously captured will be sampled for age, sex, and length (ASL). Adult coho salmon that appear to be in good health will be marked with a uniquely numbered T-bar anchor tag and a secondary mark will be used to identify sampled fish, which will prevent double sampling in the event of primary tag loss. During Event 1, the secondary mark used will be one of various combinations of operculum punches identified in Table 2. Fish that are sampled during Event 2 will receive a single punch on the lower left operculum (LLOP); carcasses encountered during surveys will also be sampled for ASL data and will additionally be marked by multiple slashes on the left side of the carcass to prevent double sampling.

If run sizes are similar to what they were in the fall of 2014, we expect there will be 9,000 escaping fish. To achieve the precision criteria of estimating the true value within 45% of the estimate, 80% of the time, tagging 152 fish in Event 1 and inspecting 444 fish in Event 2 will be required. Crews will attempt to tag and inspect as many fish as possible.

Table 2.–Locations of operculum punches that will be used each year (2015-2017) as a secondary mark to identify adult Cowee Creek coho that have been sampled during Event I, which will prevent double sampling in the event of primary tag loss.

Date	Abbreviation	Secondary mark (operculum punch)
August 3–9	RU	right, upper
August 10–16	RM	right, middle
August 17–23	RUU	right, upper, upper
August 24–30	RMM	right, middle, middle
August 31 - September 6	RUM	right, upper, middle
September 7–13	LU	left, upper
September 14–20	LM	left, middle
September 21–27	LUU	left, upper, upper
September 28 – October 4	LMM	left, middle, middle
October 5–11	LUM	left, upper, middle

Note: All fish sampled during Event 2 of adult sampling will be marked with a lower left operculum punch.

The marked fraction (fish missing adipose fins) of adult coho salmon captured each year (2015-2017) will be used to estimate smolt abundance for the previous year (2014-2016) and marine harvest for the same year (2015-2017). All fish observed with a missing adipose fin will be scanned with a tag detector to see if it tests positive for a CWT. If the fish initially tests negative, the tag detector will be placed in the mouth for a second test. In 2015, all fish missing an adipose will be sacrificed regardless of the tag detector results. In 2016, if there were no false negatives, the project leader may opt to release fish that test negative for a CWT. Each head will be assigned an individual head tag number and will be sent to the Tag Lab for further dissection and

tag decoding. Observers will take photos and detailed notes of any fish captured that either does not test positive for a tag or has a questionable adipose clip, regardless of tag status, and the pictures will be used to help ascertain if the adipose clip might be naturally occurring or not.

Event 1 (i.e., marking event) of the adult escapement mark-recapture experiment will occur in the lower portion of Cowee Creek, between the upper extent of saltwater influence and the confluence with Davies Creek (Figure 5). Each year, sampling in lower Cowee Creek for Event 1 will begin the first week of August and will continue through the first extreme high tide cycle in early October. Most sampling will occur in pools where adult coho salmon hold. Sampling locations in the lower portion of the watershed will be accessed by foot.

Event 2 (i.e., recapture event) of the adult escapement mark-recapture experiment will occur in accessible reaches of Davies Creek, and in the Cowee Creek mainstem upstream of the confluence between the 2 streams (Figure 6). Starting the first week of September, we will initiate Event 2 sampling 1–2 days per week, while Event 1 sampling will continue for the other 4-3 days a week. After the first extreme high tide cycle in October, and continuing through the end of October, all remaining sampling will be for Event 2. Most sampling will occur in pools where adult salmon hold. Sampling locations for the second event will be accessed by foot, as well as by helicopter as funding allows.

Model Assumptions for Estimation of Coho Salmon Escapement

This 2-event closed population mark-recapture experiment is designed so that a Petersen-type estimator may be used to estimate abundance. For the estimate of abundance to be unbiased, certain assumptions must be met (Seber 1982). These assumptions, expressed in the circumstances of this study, along with their respective design considerations and test procedures, are:

Assumption I: The population is closed to births, deaths, immigration, and emigration.

Considering the life histories of coho salmon, there should be no recruitment between sampling events. First event sampling (marking) will begin prior to any significant passage of fish past the tagging sites and will continue through the run until passage has dropped to near zero. There is freshwater sport harvest that occurs on the river. The SWHS has estimated harvest to be 220 (SE 110) in 2013, (Appendix A1) the most recent year available. If this occurred in 2014 it would have been less than 3% of the total estimated escapement. So any bias as a result of harvest is expected to be small.

Assumption II: Marking and handling will not affect the catchability of coho salmon in the second event.

There is no explicit test for this assumption because the behavior of unhandled fish cannot be observed. However, an attempt will be made to meet this assumption by minimizing holding and handling time of all captured fish. Any obviously stressed or injured fish will not be tagged.

Assumption III: Tagged fish will not lose their marks between sampling events and all marks are recognizable and detected.

Adult coho that appear to be in good health will be marked with a uniquely numbered T-bar anchor tag and a secondary mark will be used to identify sampled fish, which will prevent double sampling in the event of primary tag loss. The secondary mark used will be one of various combinations of operculum punches identified in Table 2.
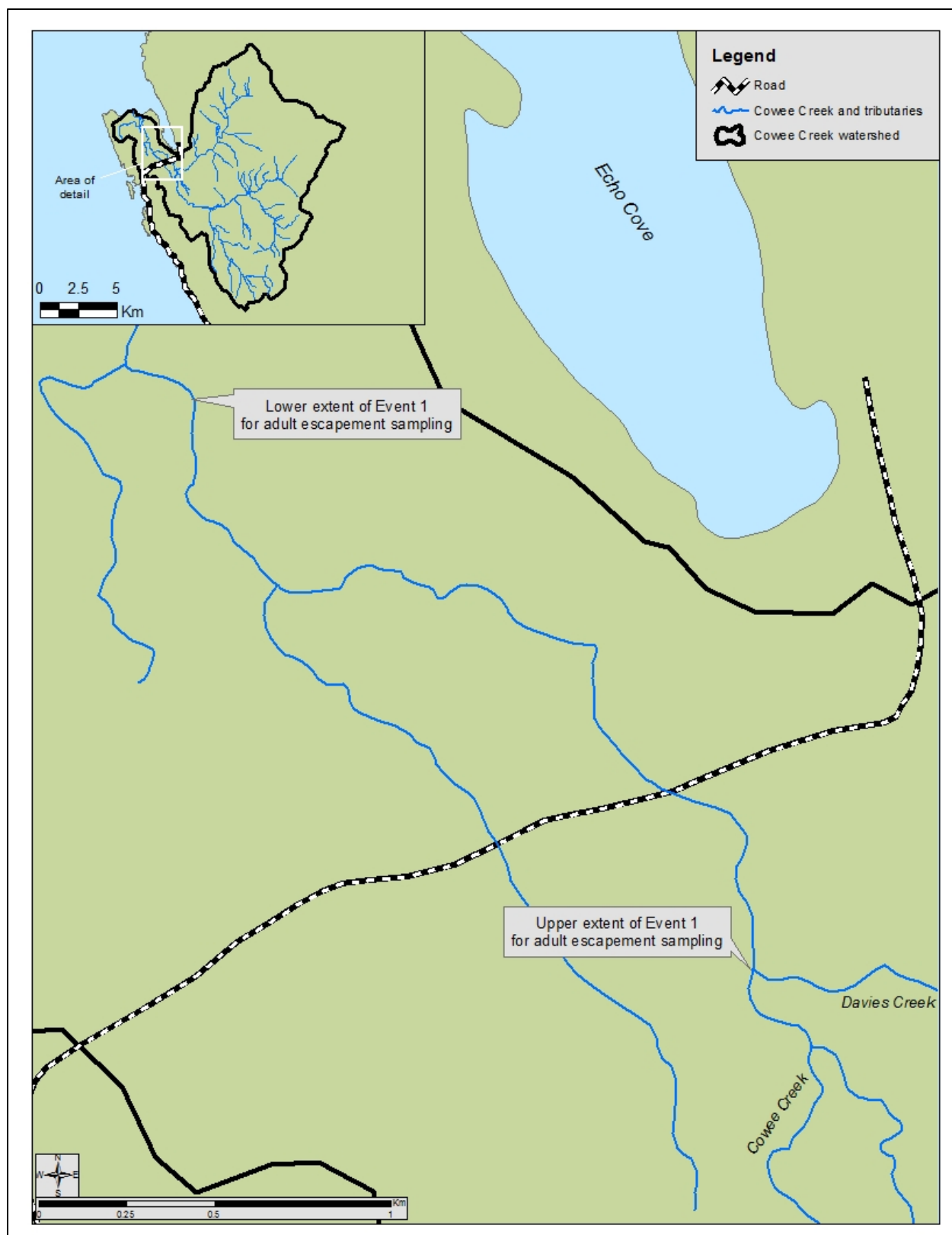
Figure 5.–Lower portion of Cowee Creek watershed where Event 1 of adult coho salmon escapement mark-recapture sampling will occur in 2015-2017, Southeast Alaska.
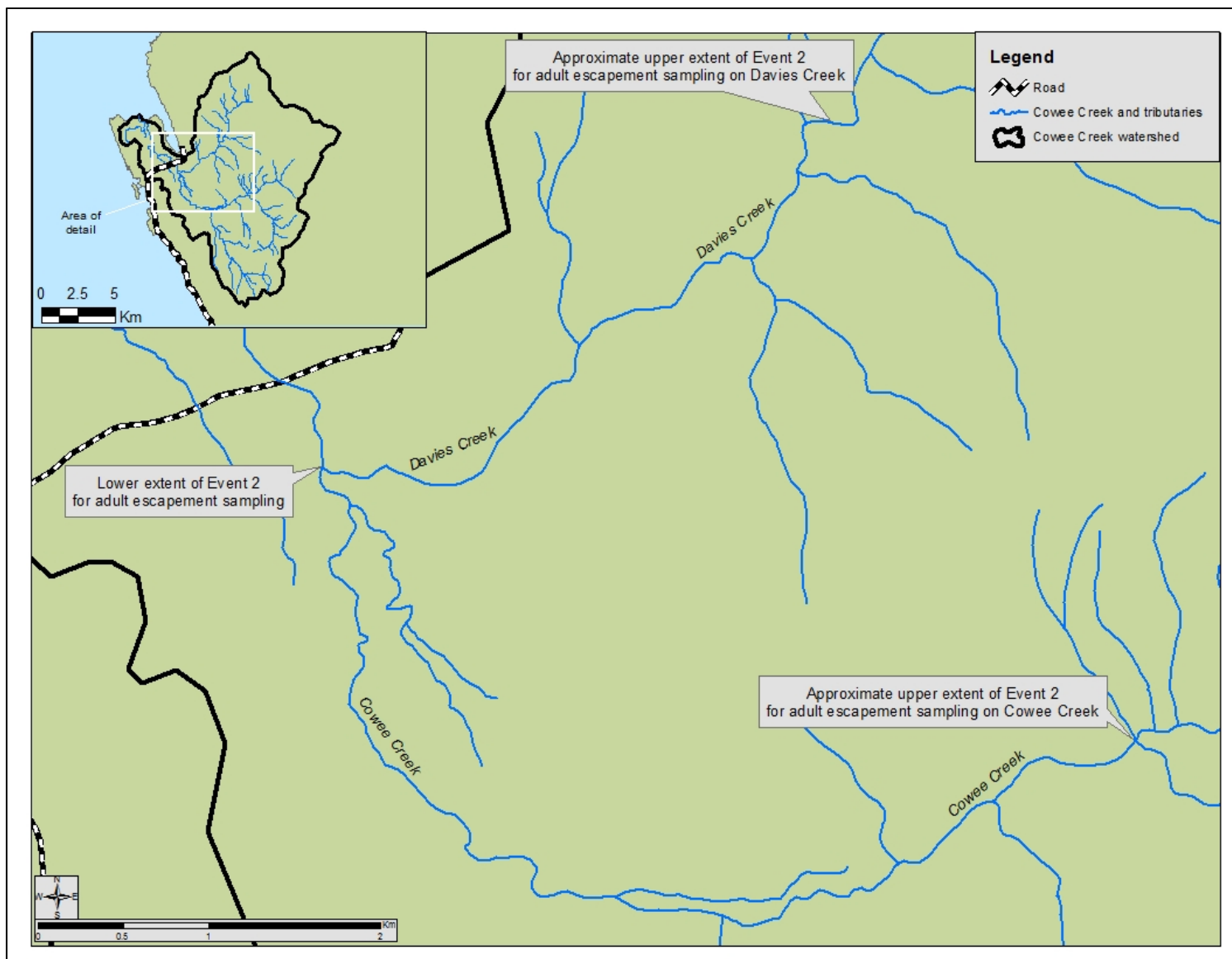
Figure 6.–Upper portion of Cowee Creek watershed where Event 2 of adult coho salmon escapement mark-recapture sampling will occur in 2015-2017, Southeast Alaska.

Assumption IV: One of the following 3 conditions will be met:

    A1. All coho salmon will have the same probability of being caught in the first event; or

    A2. All coho salmon will have the same probability of being captured in the second event; or,

    A3. Marked fish will mix completely with unmarked fish between samples.

Equal probability of capture will be evaluated by time, area, size, and sex. The procedures to analyze sex and length data for statistical bias due to gear selectivity are described in Appendix E1. If different probabilities are indicated, abundance estimates will be stratified within size groups. In this experiment, it is unknown whether marked and unmarked fish will mix completely.

To further evaluate the 3 conditions of this assumption, contingency table analyses recommended by Seber (1982) and described in Appendix E2 will be used to detect significant temporal or geographic violations of assumptions of equal probability of capture. Based on previous experience, it is anticipated temporal violations of these assumptions will be detected, and a Petersen-type model would yield a biased estimate. Therefore, abundance will most likely be estimated according to models developed by Darroch (1961) for a 2-event mark-recapture experiment on a closed population when temporal or spatial distributions of fish affect their probabilities of capture.

If the escapement of coho salmon into Cowee Creek in 2015-2017 is approximately 9000 fish, as estimated in 2014, at least 361 fish need to be marked during Event 1 and 361 fish need to be inspected for marks during Event 2 to achieve the precision criterion for Objective 4 (Robson and Regier 1964) assuming a Chapman (1951) model can be used to estimate abundance. If a Darroch model is required, and we assume a Darroch (1961) model will provide an estimate with a SE that is about 50% larger than a Chapman model, at least 540 fish will need to be handled during each event.

Temporal and Spatial Data Collection

Handheld GPS units will be used to capture smolt and adult observation data by identifying latitude/longitude for specific areas sampled and the numbers of fish collected over time.

Monitoring Stream Water Conditions

A crest staff gage currently exists on the mainstem of Cowee Creek, located on river left approximately 20 m downstream from the bridge. This gage will be checked each morning and the water level recorded to the nearest 0.1 foot. Two thermometers will remain at the staff gage location throughout the field season and will be checked at the same time the water level is obtained. One thermometer will be for water temperatures and the other will be for air temperatures; temperatures will be recorded to the nearest 0.5°C.

DATA COLLECTION

Smolt Sampling

Tag codes used will be recorded on the Coded Wire Verification Form (Appendix D1), as well as the Tagging and Release Information Form (Appendix D2); both forms are located on the Tag Lab's website. For each roll of tags used, a short section of the spool of coded wire will be taped to the Coded Wire Verification Form (Appendix D1) on the first day of tagging to identify which code is used for each of the 2 size classes. All tag and recapture data will be recorded daily on

the form entitled Salmon Smolt CWT Daily Log (Appendix D3). The data on the Daily Log will be used to record daily environmental data, catch, tagging, release, and recapture data. A new daily log will be filled out for each day of operation. Magnus et al. (2006) describes in detail the methods that will be used for tagging coho smolt.

Daily procedures will be as follows:

1. Record air and water temperature to nearest 0.5°C and stream water level to the nearest 0.1 foot. Climatological data should be collected at the same time each day and recorded on the Daily Log (Appendix D3).

2. Remove fish from traps, sort coho smolt from other species and only transport coho smolt ≥75 mm FL to the tagging station. Record coho trap catches on the Salmon Smolt Capture and GPS Location Form (Appendix D4)**.**

3. Inspect each live coho smolt ≥75 mm and count the number with adipose clips. Test all recaptures for tag retention, then release. Record the number caught with and without CWTs on the Daily Log (Appendix D3).

4. Inject all live fish with a CWT and check each fish for a tag by passing it through the tag detector. If the detector does not sense a tag, retag the fish and tally all retags on a hand counter (retags are counted separately to ensure they are not counted twice). Write the beginning and ending tagging machine numbers on the daily log and record tallies for retags, mistags (i.e., goofs, misses, etc.), and practice tags. Show your calculations for the number of tags used.

5. Select every 25th coho smolt for sampling as described below.

6. Count the number of mortalities and record on the Salmon Smolt CWT Daily Log (Appendix D3).

7. At 0900–1000 hrs the following day, check all fish for any overnight mortality and randomly select 100 representative fish (or all fish if <100 were tagged) for each size class to check for tag retention. Record results on the Salmon Smolt CWT Daily Log (Appendix D3). If tag retention is 98% or greater, count and record mortalities, record results, then transport fish to the release site and release all fish. Retag all fish that test negative. If tag retention is less than 98%, reprocess the entire batch as described above and retag any that test negative.

Every 25th coho salmon smolt tagged will be measured from snout to fork of tail (FL) to the nearest 1 mm, weighed to the nearest 0.1 g, and sampled for scales. Twelve to 15 scales will be removed from the preferred area on the left side of the coho salmon smolt (Scarnecchia 1979) and will be sandwiched between two 1- x 3-in microscope slides and numbered consecutively for each sampled fish. Slides will be taped together and the unique number and length of each fish will be written on the frosted portion of the bottom slide according to scale position on the slide. Fish-slide number, length, location, date, and sampler's initials will be included on the Salmon Smolt Length, Weight, and Scale Samples Form (Appendix D5). Ages will be estimated postseason.

Instructions to improve the ability to read scales, as determined by staff experience, are:

1. Clean the scales, spread them out so they do not touch,
2. Do not tape over any scales, and
3. Make sure slides and slide covers are accurately labeled.

Adult Escapement Sampling

Data collected for each adult coho salmon captured during Event 1 of escapement surveys will be recorded on the Cowee Creek Adult Coho ASL Form (Appendix D6). Information to be recorded includes: location (lower Cowee will be circled for Event 1); sampling crew; and comments about weather and water conditions. For each fish captured, the following data will be recorded: date; GPS waypoint and associated error; cumulative fish number (each newly captured fish will be sequentially numbered to keep track of the total number of coho salmon inspected and is not to be confused with anchor tag number because not all coho salmon will necessarily be tagged); gear type used for capture (T = tangle net, B = beach seine, Sp = sport, Sn = snag); sex (M = male, F = female; determined by examining external secondary maturation characteristics); scale card number, scale sample number on the card (1–10), length (to the nearest 5 mm MEF measurement), anchor tag number, cinch tag number (for fish that are missing their adipose fin and are sacrificed to have their head sent to the Tag Lab for CWT retrieval), operculum punch applied (Table 2), condition of the fish (1 = bright; 2 = slight coloration; 3 = obvious coloration, prespawn; 4 = postspawn; 5 = carcass), and any other comments the samplers might have about the fish (e.g., tag number and operculum punches for recaptured fish, presence of an adipose clip, presence of sea lice, wounds, etc.).

Each newly captured coho salmon should have a row of data associated with it on the ASL form, even if it does not receive an anchor tag. Fish that are recaptured will also have a row on the ASL form; however, only the date, anchor tag number, operculum punch observed, condition, and comments will be recorded.

To determine the age of each coho sampled, scale samples will be collected using methods adapted from standard ADF&G procedures (ADF&G 1994) and those described in Welander (1940). Five scales will be taken from the left side of the fish from the preferred area (2 scale rows above the lateral line, along a diagonal line between the posterior insertion of the dorsal fin and anterior insertion of the anal fin). Three scales will be taken 2 rows up from the lateral line and 1 inch apart (the center scale is considered to be the preferred scale), and 2 scales will be taken 4 rows up from the lateral line, 0.5 inch to the right and 0.5 inch to the left of the preferred scale. Scales will be cleaned off, moistened slightly, then affixed to a completely labeled gum card (species; card number; locality = Cowee Creek or Davies Creek; stat. code = 115-20-062 for Cowee Creek or 115-20-063 for Davies Creek; date; gear; collectors = last names; remarks = weather, missing scales, etc.).

It will be very important to completely label gum cards and forms so that the scales and data can be matched up in the aging lab. Each scale will be mounted on the card in uniform direction, which will be with the anterior side up and the outward (i.e., sculptured or textured) side of the scale facing out. All five scales taken from an individual coho will be mounted in one column on the card (i.e., scales from fish #1 will be placed on the card over box 1, 11, 21, 31, and below 31). Scale samples from 10 fish will be mounted on each gum card and the scale card and scale numbers will be recorded on the Cowee Creek Adult Coho ASL Form (Appendix D6). If for some reason scales are not collected from a fish, that column on the scale card will be crossed off in

pencil and "no scales for fish #_" noted in the comments box. For example, recaptured fish will be released without taking scales. It will be very important to keep the gum cards dry and free of dirt; excessive moisture will dissolve the glue on the card, which can lead to scales falling off the card or washing out of alignment. Running glue and dirt can also obscure ridges on the scales, resulting in unreadable imprints. Scales should be remounted on a new card, at the end of the day, if they have been sampled in extremely wet conditions, if the scales are dirty, or if the scales are not mounted in uniform direction.

The sex of each fish sampled will be determined by visually inspecting external secondary maturation characteristics. As they mature, males develop hooked upper and lower jaws and a slight hump (Mecklenburg et al. 2002). Females have prominent bellies compared to males (Johnson 2013) and as they become more sexually mature, it is also common for them to develop a protruded vent.

In 2015, all coho salmon captured with an adipose fin clip will be sacrificed, sampled for ASL data, then the head will be tagged around the jaw with a numbered cinch strap obtained from the Tag Lab. During 2016, the project leader may choose to release fish that test negative for presence of a CWT, if the false negative rate in 2015 is zero. The cinch strap number will be recorded on the Cowee Creek Adult Coho ASL Form (Appendix D6). Heads with cinch straps will be preserved in a refrigerator or freezer and will be delivered to the Tag Lab within 2 business days of the head being collected. Each head will be clearly labeled with the capture site, date, species, sex, and length (in mm MEF). Each day a head is collected, samplers will complete a Southeast Region Rack and Escapement Sampling Form (Appendix D7), which will be submitted to the Tag Lab along with the head.

Data collected for each adult coho salmon captured during Event 2 of escapement surveys will be recorded on the Cowee Creek Adult Coho ASL Form (Appendix D6). Information to be recorded includes: location (upper Cowee or Davies Creek will be circled for Event 2); sampling crew; and comments about weather and water conditions. For each fish captured, the following data will be recorded: date; GPS waypoint and associated error; cumulative fish number (each newly captured fish will be sequentially numbered to keep track of the total number of coho salmon inspected); gear type used for capture (T = tangle net, B = beach seine, Sp = sport, Sn = snag, Dn = dip net); sex (M = male, F = female; determined by examining external secondary maturation characteristics); scale card number, scale sample number on the card (1–10), length (to the nearest 5 mm MEF measurement), anchor tag number (for recaptured fish), cinch tag number (for fish that are missing their adipose fin and are sacrificed to have their head sent to the Tag Lab for CWT retrieval), operculum punch applied (LLOP) or observed (for recaptured fish), condition of the fish (1 = bright; 2 = slight coloration; 3 = obvious coloration, prespawn; 4 = postspawn; 5 = carcass), and any other comments the samplers might have about the fish (e.g., note fish as "unmarked" for new captures, tag number and operculum punches for recaptured fish, presence of an adipose clip, presence of sea lice, etc.).

Each newly captured coho salmon should have a row of data associated with it on the ASL form and will be identified as "unmarked" in the comments section. Fish that are recaptured will also have a row on the ASL form; however, only the date, anchor tag number, operculum punch observed, condition, and comments will be recorded.

Temporal and Spatial Data Collection

A GPS waypoint will be collected at smolt and adult capture locations. For smolt sampling, each waypoint taken and the associated GPS accuracy level (i.e., error in meters) will be recorded on the Salmon Smolt Capture and GPS Locations form (Appendix D4). For adult sampling, each waypoint taken and the associated GPS accuracy level will be recorded on the Cowee Creek Adult Coho ASL Form (Appendix D6).

Monitoring Stream Water Conditions

Each morning, the following information will be recorded on the Cowee Creek Daily Environmental Conditions Form (Appendix D8): the water level observed on the Cowee Creek crest staff gage (to the nearest 0.1 foot); water temperature (to the nearest 0.5°C); air temperature (to the nearest 0.5°C); and general weather or water comments (e.g., sunny, windy, raining, clear water, glacial water, etc.). The gage and thermometers will be located on river left, approximately 20 m downstream from the bridge.

DATA REDUCTION

The leader of the field crew will ensure that data forms are kept up to date at all times and will check all data for errors. Data will be sent to the office at regular intervals and inspected for accuracy and compliance with sampling procedures. Data will be transferred from forms to EXCEL®[1] files. When input is complete, data lists will be obtained and checked against the original field data. Electronic data files will be used to check tagging totals on data forms, to identify lengths less than prescribed guidelines, sampling rates for age, weight, and length, and for data to be included on forms submitted to the Tag Lab.

Forms that will be submitted to the Tag Lab include the Coded Wire Verification Form (Appendix D1), the Tagging and Release Information Form (Appendix D2), and the Southeast Region Rack and Escapement Sampling Form (Appendix D7). The Tag Lab is the clearinghouse for all information on CWTs. All CWT data (sampled fish, decoded tags, location, data type, samplers, etc.) are archived and accessible on a permanent ADF&G statewide database and once per year are provided to the permanent coastwide database administered by the Pacific States Marine Fisheries Commission.

Accumulated data for this project, including both juvenile and adult sampling, will be stored in Juneau at the following location: S:\DJ_ReportingPlanning\CoweeCreek_FreshwaterAssessment\Data\DataEntry. A final, edited copy of the data, along with a data map, will be sent to Research and Technical Services (RTS) in Anchorage electronically for archiving.

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[1] This and subsequent product names are included for a complete description of the process and do not constitute product endorsement.

DATA ANALYSIS

Smolt Abundance

The mark-recapture experiment based on coho salmon smolt and returning adults will use Chapman's modification of the Petersen Method (Seber 1982) to estimate abundance of smolt and its variance:

$$\hat{S} = \frac{(M+1)(C+1)}{(R+1)} - 1 \tag{1}$$

$$Var(\hat{S}) = \frac{(K+1)(n+1)(K-k)(n-k)}{(k+1)^2(K+2)} \tag{2}$$

where $\hat{S}$ is estimated abundance of smolt in a particular year (2015 or 2016), M is the number of marked smolt (all tag codes) released alive into the population in that same particular year, C is the total number of adults inspected for marks from the particular year) that return a year later, and R is the number of adults with missing adipose fins in the C samples.

Several conditions must be met for this estimator to be unbiased for the experiment as noted earlier in this plan.

Equal survival between tagging groups will be evaluated using contingency table analysis (Agresti 2007) to test for lack of independence between tagging group and probability of recovery during adult sampling. If the null hypothesis of independence is not rejected, at least S2 (from assumptions listed earlier in this plan) is assumed to be satisfied and equations (1) and (2) will be used to estimate abundance after pooling the tag codes. If lack of independence is detected between the adult tag recovery rate, a weighted variant of Chapman's modification to the Petersen estimator will be used to estimate abundance of Cowee Creek smolt:

$$\hat{S}'' = \frac{(\hat{A}M_1 + M_2 + 1)(\hat{C}'+1)}{\hat{A}(R_1 + \hat{\pi}_1 R_3) + (R_2 + \hat{\pi}_2 R_3) + 1} - 1 \tag{3}$$

where A is the ratio of the catchability coefficients for larger (>85 mm FL) to smaller (≤85 mm FL) Cowee Creek smolt during the marking event and π_i is the fraction of adults that were smaller or larger Cowee Creek smolt during the marking event.

The estimate of A is used to adjust for differences in catchability during the marking event such that $A>1$ when larger smolt are more catchable, and $A<1$ when larger smolt are less catchable. Because some recaptured fish are not sacrificed to find tags or some marked adults do not contain tags, π_i's are used to assign recaptured fish of unknown pedigree to the appropriate smolt size group. The estimate of π is calculated:

$$\hat{\pi}_i = \frac{T_i}{T_1 + T_2} \tag{4}$$

where T_i is the number of all tags representing a smolt size group ($i = 1, 2$) recovered or recaptured from adult salmon regardless of how or where recovered or recaptured.

Evidence for smolt not having equal probability of being marked regardless of size can be found through calculations based on estimates of relative freshwater age composition of smolt and adults. If $\hat{p}$ is the estimated fraction of all <u>adults</u> that are of freshwater-age-1, if $\hat{\phi}_1$ is the estimated fraction of <u>smolt</u> in the smaller-size group that were freshwater-age-1, and if $\hat{\phi}_2$ is the estimated fraction of <u>smolt</u> in the larger size group that were freshwater-age-1, an estimate of the ratio of catchability coefficients for larger to smaller smolt is (see Appendix C1 for derivation):

$$\hat{A} = \frac{T_2(\hat{\phi}_2 - \hat{p})}{T_1(\hat{p} - \hat{\phi}_1)} \tag{5}$$

Simulation results (see below) will be used to evaluate if this estimated rate is statistically different than 1.

Variance and 95% credible interval for $\hat{S}'$ or $\hat{S}''$ and $\hat{A}$ will be estimated using empirical Bayesian methods (Carlin and Louis 2000). Using Markov Chain Monte-Carlo techniques, posterior distributions for the estimated parameters will be generated by collecting 100,000 simulated values of the parameter components and parameters that are calculated using equations described from simulated data. Simulated values are modeled from observed data using the appropriate binomial or multinomial distributions.

Smolt Age Composition

Proportions by age will be estimated by:

$$\hat{p}_j = \frac{n_j}{n} \tag{6}$$

$$\text{var}[\hat{p}_j] = \frac{\hat{p}_j(1 - \hat{p}_j)}{n - 1} \tag{7}$$

where p_j is the proportion in the population in group j, n is sample size, and n_j *is the subset of* n that belong to group j. The systematic selection of samples implies proportional sampling and reduces bias from any inseason changes in age composition.

Estimates of Smolt Mean Length and Weight

Standard sample summary statistics will be used to estimate mean length- and weight-at-age and associated variances (Thompson 2002).

Adult Marine Harvest

The contribution r_{ij} of a release group j to a fishery stratum i is estimated:

$$\hat{r}_{ij} = \hat{N}_i \left[\frac{m_{ij}}{\lambda_i n_i} \right] \hat{\theta}_j^{-1} \tag{8}$$

where

N_i = total harvest in fishery stratum i,

n_i = number of fish inspected in fishery stratum i (the sample),

$\lambda_i = (a_i' t_i')/(a_i t_i)$ is the decoding rate for CWTs from recovered salmon,

a_i = number of fish which were missing an adipose fin,

a_i' = number of heads that arrived at the lab,

t_i = number of heads with CWTs detected,

t_i' = number of CWTs that were dissected from heads and decoded,

m_{ij} = number of CWTs with code(s) of interest, and

θ_j = fraction of the cohort tagged with code(s) of interest.

Note: j represents the different tagging codes. If no statistical difference in survivability or capture is found between the tagging codes, then $j = 1$ and the equations may be simplified. See Bernard and Clark (1996) for further details.

Because N_i is estimated with error in sport fisheries, unbiased estimates of the variance of $\hat{r}_{ij}$ will be obtained using the appropriate large-sample equations in Table 2 of Bernard and Clark (1996), including the covariance between estimated harvests of cohorts within strata.

The total harvest for a cohort was calculated as the sum of strata estimates:

$$\hat{H} = \sum_i \sum_j \hat{r}_{ij} \tag{9}$$

$$Var\left[\hat{H}\right] = \sum_i \sum_j v\left[\hat{r}_{ij}\right] \tag{10}$$

Commercial catch data for the analysis will be summarized by ADF&G statistical week and district (for gillnet and seine fisheries) or by period and quadrant for troll fisheries (e.g., see Clark et al. 1985). Sport harvest estimates from ADF&G Statewide Harvest Survey reports (e.g., Jennings et al. 2011) will be apportioned using information from sampled marine sport fisheries to obtain estimates of total harvest by biweek and fishery. Sport fish CWT recovery data will be obtained from Tag Lab reports and summarized by biweek and fishery (e.g., biweek 16 during the Sitka Marine Creel Survey) to estimate contribution. In most cases, CWTs of interest may be recovered in only a few of the sport fish sampling strata that defined the fishery biweek. Assuming that the harvests of fish with CWTs of interest are independent of sampling strata within fishery biweeks, harvests and sampling information will be totaled over the fishery biweek to estimate contributions.

Adult Escapement

A 2-sample mark-recapture model will be used to estimate the escapement of adult coho salmon into Cowee Creek, during each year in 2015-2017. The appropriate abundance estimator will depend on the results of the aforementioned tests (Appendices E1 and E2). If stratification is not needed, Chapman's (1951) version of Petersen's abundance estimator for closed populations (Seber 1982) will be used:

$$\hat{N} = \frac{(M+1)(C+1)}{(R+1)} - 1 \tag{11}$$

where $\hat{N}$ = estimated number of coho salmon, M = the number of coho salmon marked during Event 1 sampling, C = the number of coho salmon inspected for marks during Event 2 sampling, and R = number of marked coho salmon recaptured during Event 2 sampling.

If temporal-geographic stratification is not required but stratification by size or sex is (Appendix E1), the data will be fully stratified and estimates for each stratum will be generated using equations (1–3). These stratum estimates summed to estimate total abundance and variance.

An estimate of the variance for $\hat{N}$ will be obtained through bootstrapping (Efron and Tibshirani 1993), using the methods in Buckland and Garthwaite (1991). The 4 components of the mark-recapture experiment include:

- $M - R$: fish that are marked during Event 1 but not recaptured;

- $C - R$: unmarked fish examined during Event 2;

- R: marked fish recaptured during the Event 2; and

- $\hat{N} - M - C + R$: estimated number of fish not seen during either event;

These components will be modeled as a multinomial process using the proportions calculated from experimental data. A bootstrap realization (b) will be a randomized draw from this multinomial distribution. Subsequently, for each bootstrap sample $\hat{N}_b^*$ will be calculated using equation (1).

A minimum of 1,000,000 bootstrap samples (B) will be so drawn. The approximate variance will be calculated as:

$$\text{var}(\hat{N}) = \frac{\sum_{b=1}^{B} (\hat{N}_b^* - \bar{\hat{N}}^*)^2}{B - 1} \tag{12}$$

where $\bar{\hat{N}}^*$ is the average of the $\hat{N}_b^*$. Confidence intervals will be obtained using the percentiles of the distribution of the B bootstrap samples.

If geographic or temporal stratification is required, estimation of abundance will follow procedures described by Darroch (1961). Initial modeling will be conducted using the computer program SPAS (Arnason et al. 1996). If stratification by size is required, size stratification will be conducted first and methods to correct for geographic or temporal capture heterogeneity will be applied independently to each size stratum. The contingency tables described in Appendix E2 will be further analyzed to identify a) Event 1 strata (individual or contiguous groupings of temporal-geographic categories) where probability of recapture during the second event is homogeneous within strata and different between strata; and b) Event 2 strata where marked: unmarked ratios are homogeneous within strata and different between strata. Temporal categories generally will consist of groupings of sample data collected by week. Stratification will also be guided by environmental conditions encountered during data collection (stream stage height and rainfall). If the initial stratification does not result in an admissible maximum-likelihood (ML) estimate of abundance, further stratification may be necessary before an admissible estimate can be calculated. Nonadmissible estimates include failure of convergence of

the ML algorithm in SPAS or convergence to estimators with estimated negative capture probabilities or estimated negative abundance. Goals in this case are always that observations within the pooled stratum should be as homogeneous as possible with respect to capture, migration, and recapture (Arnason et al. 1996).

A goodness of fit (GOF) test (provided in SPAS) that compares the observed and predicted statistics will indicate the adequacy of a stratified model. Once a stratification is identified that results in an admissible estimate of abundance, GOF will be evaluated. Further stratification, according to the guidelines described above, may be necessary to produce a model and abundance estimate with a satisfactory GOF. In general, the model selected will be that which provides an admissible estimate of abundance where no stratification guidelines are violated, no significant evidence of lack of fit is detected, and the smallest number of strata parameters are estimated for the model. This model will usually yield the smallest ML estimate of variance for the abundance estimate.

If the Darroch (1961) procedure is used to estimate abundance and the number of first event (s) and second event (t) strata in the preferred model is not equal, further modeling will be conducted to identify an alternative preferred model with s equal to t. The reason for the alternative model is that an analytical solution may be calculated for the ML estimate of abundance using equations provided in Seber (1982) – no ML search algorithm is required. An analytical solution greatly simplifies the bootstrap modeling that will be used to estimated variance (described below). For $s < t$, typically the largest (most recaptures) marking strata in the preferred model can be divided into 2 or more smaller strata to increase s. For $s < t$, the Event 2 strata will be divided to provide a larger t. Several alternative models, constructed in the manner, may be explored using the SPAS software. For all but the most ill-behaved data sets, this process will commonly produce one or more alternative models where $s = t$ and the ML estimates of abundance and SE are nearly identical to, and not statistically discernable from, those estimates from the preferred model. The chosen alternative model will be that for which the parameter estimates most closely match the preferred model.

Using the preferred alternative model ($s = t$), bootstrap methodology (Efron and Tibshirani 1993) will be used to estimate variance and confidence intervals. The procedures described above for the Chapman estimator will generally be followed, except a more complex multinomial distribution for fish in the population will be required for the Darroch estimator. There will be (s)(t) capture histories for recaptured coho salmon, s capture histories for salmon marked but never recaptured, t histories for coho salmon captured upstream in the Event 2 sampling without marks, and one history for all salmon never caught.

Similar to what was described above for the Chapman estimator, a minimum of 1,000,000 bootstrap samples (B) will be drawn. For each bootstrap iteration, a randomized realization of the components of the partially stratified Darroch model will be drawn. An estimate of $\hat{N}$ will then be calculated for each of the B bootstrap samples using the methods describe in section 11.1 of Seber (1982). Equation (12) will be used to estimate the variance of the abundance estimate.

SCHEDULE AND DELIVERABLES

Dates for field and office activities associated with this project are included in Table 3. Note that the dates identified are approximate and that there will not be any activities associated with juvenile field work in 2017.

Table 3.–Schedule for all office and field related activities for this project, 2015.

Date	Activity	Years
March 2–April 17	Preparations for juvenile field sampling	2015, 2016
April 20–June 12	Smolt trapping and tagging	2015, 2016
June 15–19	Field clean-up	2015, 2016
June 22–26	Data entry	2015, 2016
June 29–July 31	Preparations for adult field sampling	2015, 2016, 2017
August 3–October 30	Adult inriver recapture	2015, 2016, 2017
September	Federal aid performance report due	2015, 2016, 2017
November 2–6	Field clean-up	2015, 2016, 2017
November 9–13	Data entry	2015, 2016, 2017
November 16-March 1	Scale aging (juvenile and adult)	2015, 2016, 2017

Each year, a federal aid performance report will be prepared in September detailing all activities performed and any results produced during the reporting period. A Fisheries Data Series report will be prepared by December 31, 2018 that will summarize the CWT operations for 2014-2016, information obtained from CWT recoveries, the 2015-2017 marine harvest of Cowee Creek originated coho stock, as well as the 2015-2017 adult escapement for Cowee Creek coho salmon.

RESPONSIBILITIES

Kercia Schroeder, Fishery Biologist II (Douglas).
> Project leader. Oversees all aspects of the project, including study design, planning, budgeting, equipment acquisition, training, logistical matters, data collection, data entry, QA/QC, etc. Writes all required documents related to the project.

Jeff Nichols, Regional Research Coordinator (Douglas).
> Oversees and reviews the following aspects of the project including study design; planning, budgeting, equipment acquisition, training, and supervision of project personnel. Will review all operational plans and reporting documents. Assists with field work and data collection.

Vacant, Fish and Wildlife Technician III (Douglas).
> Assists with all aspects of field work and data collection, as well as installation and removal of field equipment. This position will be the field crew leader and will be responsible for making sure all data is accurate, organized, and is provided to the project leader in a timely manner.

Vacant, Fish and Wildlife Technician II (Douglas).
 Assists with all aspects of field work and data collection, as well as installation and removal of field equipment.

Vacant, Fish and Wildlife Technician II (Douglas).
 Assists with all aspects of field work and data collection, as well as installation and removal of field equipment.

Sarah Power, Biometrician II (Douglas).
 Responsible for biometric input including study design, writing of operational plan, analysis and coauthoring of all reporting documents.

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APPENDIX A. STATEWIDE HARVEST SURVEY RESULTS FOR JUNEAU ROADSIDE FISHERIES

Appendix A1.–Statewide Harvest Survey results and 15 year average for number of coho salmon harvested in Juneau roadside fisheries from 1999 to 2013. Standard errors (SE) are included in parenthesis, below each estimate.

Juneau roadside stream name	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Average
Cowee Creek	393	575	312	644	989	456	588	498	230	468	1,270	505	458	228	220	522.3
	(165)	(242)	(164)	(212)	(427)	(226)	(282)	(161)	(113)	(186)	(385)	(265)	(229)	(96)	(110)	
Montana Creek	230	324	301	658	361	90	264	349	264	245	438	285	571	443	214	335.8
	(117)	(162)	(119)	(218)	(170)	(49)	(146)	(194)	(160)	(110)	(227)	(155)	(286)	(268)	(144)	
Peterson Creek and Salt Chuck	11	63	19	178	158	0	0	98	101	38	250	60	ND	ND	ND	81.3
	(11)	(61)	(19)	(107)	(116)	(0)	(0)	(77)	(59)	(22)	(234)	(63)	-	-	-	
Fish Creek (Douglas Island)	0	111	73	111	35	0	197	0	110	24	0	376	35	45	194	87.4
	(0)	(43)	(36)	(57)	(26)	(0)	(134)	(0)	(75)	(17)	(0)	(383)	(20)	(34)	(196)	
Other Juneau road system	262	0	68	114	101	13	24	9	0	0	118	15	30	271	55	72.0
	(179)	(0)	(62)	(53)	(61)	(13)	(24)	(9)	(0)	(0)	(97)	(14)	(30)	(145)	(28)	

Appendix A2.–Statewide Harvest Survey results and 15 year average for number of anglers fishing Juneau roadside fisheries from 1999 to 2013.

Juneau roadside stream name	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Average
Cowee Creek	589	938	875	852	1,195	880	1,044	1,143	1,221	917	1,221	845	743	812	1,193	964.5
Montana Creek	686	669	973	707	892	564	820	780	785	819	814	781	785	634	597	753.9
Peterson Creek and Salt Chuck	336	367	387	462	440	333	459	288	520	805	550	427	ND	ND	ND	447.6
Fish Creek (Douglas Island)	808	981	1,192	787	972	1,032	1,196	695	1,018	1,099	908	594	743	707	785	901.2
Other Juneau road system	433	493	719	742	760	699	623	824	708	407	683	629	954	1,293	1,027	744.6

Note. The Statewide Harvest Survey does not estimate SE for number of anglers.

Appendix A3.–Statewide Harvest Survey results and 15 year average for number of days fished in Juneau roadside fisheries from 1999 to 2013. Standard errors (SE) are included in parenthesis, below each estimate.

Juneau roadside stream name	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Average
Cowee Creek	1,522	2,594	3,087	1,845	2,989	2,250	2,489	2,507	1,703	2,222	4,252	2,803	1,861	1,702	2,305	2,408.7
	(394)	(708)	(1,105)	(358)	(621)	(572)	(598)	(616)	(309)	(478)	(1,042)	(875)	(641)	(429)	(552)	
Montana Creek	2,069	2,763	3,993	3,015	2,229	1,570	1,782	1,654	2,072	2,796	4,887	2,890	2,474	1,628	1,479	2,486.7
	(567)	(646)	(1,070)	(931)	(489)	(523)	(426)	(408)	(674)	(947)	(2,252)	(978)	(614)	(567)	(506)	
Peterson Creek and Salt Chuck	906	1,249	1,613	1,469	1,275	803	1,134	800	946	1,475	1,030	1,431	ND	ND	ND	1,177.6
	(347)	(404)	(824)	(528)	(384)	(271)	(396)	(305)	(280)	(341)	(421)	(671)	-	-	-	
Fish Creek (Douglas Island)	1,627	2,068	2,359	2,234	1,533	3,022	3,926	1,819	1,981	2,215	2,119	1,945	1,695	2,182	1,990	2,181.0
	(427)	(522)	(496)	(591)	(320)	(1,033)	(983)	(477)	(387)	(523)	(549)	(689)	(580)	(1,009)	(899)	
Other Juneau road system	842	1,375	1,840	2,503	1,703	1,194	1,893	1,647	2,212	1,289	1,791	1,369	1,822	2,635	3,754	1,857.9
	(224)	(415)	(411)	(850)	(462)	(318)	(768)	(382)	(700)	(588)	(530)	(327)	(454)	(684)	(1,375)	

APPENDIX B. MARINE HARVEST ESTIMATES FOR ADULT COHO SALMON RETURNING TO COWEE CREEK

Appendix B1.– Statistics used to link the number of coho salmon smolt tagged in 2013 with the ultimate relative precision of the estimated marine harvest from adults returning to Cowee Creek in 2014.

$\theta = 0.003$ (657 escaping adults inspected, 2 with valid CWTs, 5 with adclips); smolt tagged 2,259; smolt abundance 247,736 (SE 93,104)

Stratum	Stat week	N_i or $\hat{N}_i$	$V[\hat{N}_i]$	n_i	m_i	λ_i	$\hat{r}_{ij}$	ϕ_i	$G(\hat{p}_i)$	$G(\hat{N}_i)$	$SE[\hat{r}_{ij}]$	Prob($m_{ij} > 0$)
Troll NW	33-34	183,999	0	41,605	1	0.9890	1,469	23%	0.999	0	1,468	0.632
Troll NW	35	118,919	0	20,684	1	0.9932	1,902	17%	0.999	0	1,901	0.632
Troll NW	36	129,786	0	26,417	1	0.9910	1,629	20%	0.999	0	1,628	0.632
Troll NW	37	167,938	0	27,965	1	0.9893	1,994	17%	0.999	0	1,994	0.632
Troll NW	38-39	93,092	0	14,500	1	0.9844	2,142	16%	1.000	0	2,142	0.632
Drift NE	36	16,138	0	7,175	1	0.9880	748	44%	0.999	0	747	0.632
Drift NE	37	22,106	0	6,448	2	0.9770	2,305	29%	0.500	0	1,629	0.865
Drift NE	38	20,161	0	7,408	2	1.0000	1,788	37%	0.499	0	1,264	0.865
Drift NE	39	15,629	0	5,054	1	1.0000	1,016	32%	0.999	0	1,015	0.632
Drift NE	40	2,778	0	1,535	1	1.0000	595	55%	0.998	0	594	0.632
		770,546		158,791	12		15,587	21%			4,814	

Appendix B2.- Statistics from the number of coho salmon smolt tagged in 2014, combined with harvest information from the previous year (2014) to estimate relative precision of the estimated marine harvest from adults returning to Cowee Creek in 2015. Similar numbers will be expected for subsequent years.

$\phi = 0.21$ (average all fisheries); $\theta = 0.009$ valid CWT (higher adclip ratio) Approximately 250,000 smolt and 7000 tagged

Stratum	Stat week	N_i or $\hat{N}_i$	$V[\hat{N}_i]$	n_i	m_i	λ_i	$\hat{r}_{ij}$	ϕ_i	$G(\hat{p}_i)$	$G(\hat{N}_i)$	$SE[\hat{r}_{ij}]$	Prob($m_{ij} > 0$)
Troll NW	33-34	183,999	0	41,605	3	0.9890	1,469	23%	0.333	0	847	0.950
Troll NW	35	118,919	0	20,684	3	0.9932	1,902	17%	0.333	0	1,097	0.950
Troll NW	36	129,786	0	26,417	3	0.9910	1,629	20%	0.333	0	940	0.950
Troll NW	37	167,938	0	27,965	3	0.9893	1,994	17%	0.333	0	1,151	0.950
Troll NW	38-39	93,092	0	14,500	3	0.9844	2,142	16%	0.333	0	1,236	0.950
Drift NE	36	16,138	0	7,175	3	0.9880	748	44%	0.332	0	431	0.950
Drift NE	37	22,106	0	6,448	6	0.9770	2,305	29%	0.166	0	940	0.998
Drift NE	38	20,161	0	7,408	6	1.0000	1,788	37%	0.166	0	729	0.998
Drift NE	39	15,629	0	5,054	3	1.0000	1,016	32%	0.332	0	586	0.950
Drift NE	40	2,778	0	1,535	3	1.0000	595	55%	0.332	0	342	0.950
		770,546		158,791	36		15,587	21%			2,778	

APPENDIX C. ESTIMATION OF THE RATIO OF CATCHABILITIES

Appendix C1.–Estimation of the ratio of catchabilities.

The fraction p of adults with 1-freshwater age can be expressed as:

$$p = \frac{N_1 \phi_1 S_1 + N_2 \phi_2 S_2}{N_1 S_1 + N_2 S_2} = \frac{N_1 \phi_1 S_1 + N_2 \phi_2 B S_1}{N_1 S_1 + N_2 B S_1} = \frac{N_1 \phi_1 + N_2 \phi_2 B}{N_1 + N_2 B}$$

where N_i is smolt number by smolt size group i, S_i their survival rate, ϕ_i the fraction of the smolt group comprised of smolt age 1-freshwater, and B is the ratio of survival rates S_2/S_1. This relationship simplifies to:

$$\frac{N_1}{N_2} = \frac{B(\phi_2 - p)}{(p - \phi_1)}$$

If α_i is the capture rate of smolt, then $M_i = \alpha_i N_i$ is the number of smolt marked for groups i, and:

$$\frac{N_1}{N_2} = \frac{M_1}{M_2} \frac{\alpha_2}{\alpha_1} = \frac{B(\phi_2 - p)}{(p - \phi_1)}$$

If A is the ratio of catchability for the 2 groups of smolt, then $A = \alpha_2 / \alpha_1$ since fishing effort by definition is equal for both groups. Substitution creates:

$$A = \frac{M_2 B(\phi_2 - p)}{M_1 (p - \phi_1)}$$

A naïve estimate of A is therefore:

$$\hat{A} = \frac{M_2 \hat{B}(\hat{\phi}_2 - \hat{p})}{M_1 (\hat{p} - \hat{\phi}_1)}$$

Noting that the estimate for the ratio of survival rates is:

$$\hat{B} = \frac{T_2}{M_2} \frac{M_1}{T_1} \text{ since } B = \frac{S_2}{S_1} \propto \frac{\dfrac{T_2}{M_2}}{\dfrac{T_1}{M_1}} \text{ where } T_i \text{ is the number tags recovered from group } i$$

A simpler estimate for A is:

$$\hat{A} = \frac{T_2(\hat{\phi}_2 - \hat{p})}{T_1(\hat{p} - \hat{\phi}_1)}$$

APPENDIX D. DATA FORMS USED FOR JUVENILE AND ADULT SAMPLING

Appendix D1.–The ADF&G Coded Wire Verification Form that will be used to supply the Mark, Tag, and Age Laboratory with a sample of coded wire used to tag coho salmon at Cowee Creek.

Appendix D2.–The ADF&G Tagging and Release Information Form that will be completed and submitted to the Mark, Tag, and Age Laboratory at the end of the field season.

Alaska Department of Fish and Game
Tagging and Release Information Form

TAG CODE (1/form) : ____ AG   D1   D2   D3   D4   Beginning Seq.: _____   Ending Seq.: _____   Page [ ] of [ ]

| FOR TAG LAB USE ONLY Code Verified As _____ By_____ Date _____ | TAPE WIRE SAMPLE HERE (1/SPOOL) | SEQUENTIAL WIRE SAMPLES   First Tag   Last Tag |

GENERAL INFORMATION

Project Leader_____   Species (common name)_____

Agency_____   Brood Year_____

Division/Section (ADF&G only)_____   Stock_____

Facility_____ (leave Facility blank if Rearing Type = Wild)   Ancestral Stock_____ (leave Ancestral Stock blank if Rearing Type = Wild)

Run_____   Funding Source_____

Statistical Replicates (not embedded)_____

Experimental Narrative (brief):_____
(leave Experimental Narrative blank if Rearing Type = Wild)

Rearing Type:
H - Hatchery
M - Mixed
W - Wild

Release Type:
E - Experimental
B - Both (E + P)
I - Index (not PSC)
K - PSC key
P - Production
O - Other

Experimental Class:
(leave Experimental Class blank if Rearing Type = Wild)
A - Adult Return Timing   M - Mass Marking
B - Brood Selection   R - Remote Stocking
C - Colonization   S - Size at Release
D - Diet Trial   T - Time of Release
E - Rearing Strategy   Y - Rearing Density
F - Genetic Study   Z - Zero Check
Other:

Mark Type:
AD+CWT   AD+CWT+VI   AD+LV+CWT+TM   AD+RV+CWT+TM
AD+CWT+TM   AD+LV+CWT   AD+RV+CWT   Other:

TAGGING INFORMATION

Tagging Supervisor_____   Size of Tagged Fish_____ Grams   # Naturally Missing Ad Fins_____

1 Date Mo/Day/Yr	2 Machine Number	3 Number Injected	4 Overnight Mortality	5 Good Fin Clip Sample Ratio	6 %Good Fin Clips (to 0.1%)	7 Adjusted Tagged (3-4)	8 Tag Retention Sample Ratio	9 * % Tag Retention (to 0.1%)	10 Total Valid Tagged (7x9)
/ /				/			/		
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Grand Total (all pages)								-	

Note: Fin clip information is currently not used in tagging calculations.

RELEASE INFORMATION

Release Supervisor_____

Release Site_____

Habitat Stream #_____

Time of Release [| | |] Military Time

Release Stage:
E - emergent fry
F - fed fry
G - fingerling
P - presmolt
S - smolt
A - adult

Unmarked Fish Counting Method:
B - book
C - actual count
F - feed conversion
P - Petersen estimate
V - volumetric
W - weight estimate

Expected Survival:
N - normal
D - fish destroyed
W - serious problem

Hatchery Release Strategy:
F - forced
M - mixed
V - volitional

11 Date of Final Good Fin Clip Test	12 Final Fin Clip Sample Ratio	13 % Good Fin Clips (to 0.1%)	14 Date of Final Tag Retention Test	15 Tag Retention Sample Ratio	16 ** % Tag Retention (to 0.1%)	17 Weight (grams/fish)	Size at Release Fork Length (in mm)
DO NOT APPLY			DO NOT ENTER OVERNIGHT TEST DATA				
/ /	/		/ /	/			

18 Release Dates Began Mo/Day/Yr — Ended Mo/Day/Yr	19 Total Injected (From 3 above)	20 Overnight Morts (From 4 above)	21 Morts After Tagging	22 Surviving Tagged Fish (19-20-21)	23 Best Estimator of Good Fin Clips	24 Surviving Fish With Good Clips (22x23)
/ / / /					100%	

25 Best Estimator of Tag Retention (Either 9A or 16)	26 # of Marked Fish Having Tags (24x25)	27 # of Marked Fish that Shed Tags (24-26)	28 # of Fish Released NOT Marked but Represented by this Code	29 # of Failed Marks (22-24)	30 Total Unmarked Fish Released (28+29)	31 Total Number Fish Released (26+27+30)
				⊖		

Comments:

* Determined from a sample size of at least 200 tagged fish/machine/day   ** Determined from a sample size of at least 500 tagged fish/code upon release

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Appendix D3.–Data form to record daily environmental conditions and coded wire tagging results.

SALMON SMOLT CWT DAILY LOG
SPORT FISH DIVISION

Tagging Site: Cowee Creek (above bridge)   **Species:** coho salmon   **Date**_____

Air Temp: Min. _____° C   **Max.** _____° C

Water Temp _____° C   **Staff Gage Level** _____ft

Comments_____

---

1. TAG RETENTION (The # released today alive that were tagged yesterday) _____

TODAY'S TAGGING

2. TRAP MORTS: Fish found dead in trap or box_____ / # of marked (ad clipped) dead fish_____

3. RECAPTURES:

    a. Total with CWTs   _____ (Release immediately)

    b. Number without CWTs   _____ (Release next day after retention)

4. NEW CWTS APPLIED:

    a. Ending Number   _____ (Machine No.)

    b. Beginning Number   _____ (Machine No.)

    c. Retags   _____ (Hand counter)

    d. Subtotal (a-b-c)   _____ (Total CWTs Applied)

5. POST TAGGING MORTS: _____ (Morts)

6. NUMBER FISH HELD FOR TAG RETENTION   _____ (Hold till next day)

7. TOTAL DAILY RELEASE (1+4d-5-6)   _____

Notes:

---

1. TAG RETENTION TESTS (those fish held from the previous day):

    a. From 24hr Hold :   # of fish w/CWTs_____   # of fish w/o CWTs_____

    b. Morts: _____

    c. Retention Release: _____ (Carry over to next day

Appendix D4.–Data form used to record GPS and juvenile capture data.

SALMON SMOLT CAPTURE and GPS LOCATIONS

Year: 2015   **GPS Unit #:**_____   **Location:** Cowee Creek   **Observers:**_____

Comments:_____

| Date	Wpt # & Error (m)	# of traps checked	# of traps removed	Total # of traps	# of coho	# of DV	# of CT	Comments

*** a waypoint should only be associated with traps that are <5 m away from the place where the waypoint was captured; if you take a waypoint and place several traps that are <5 m away from that location, then place 1 additional trap and realize it's ~7 m away, then take a new waypoint for the 1 additional trap.

Appendix D5.–A representative portion of the data form for recording salmon smolt length, weight, and scale samples.

SALMON SMOLT LENGTH, WEIGHT, AND SCALE SAMPLES

Location: Cowee Creek   **Year:** 2014   **Samplers:**_____

Page ____ **of** ____

Scale Slide   **Scale Envelope**

Fish/Slide # ⟶ 001

Scotch Tape (frosted)
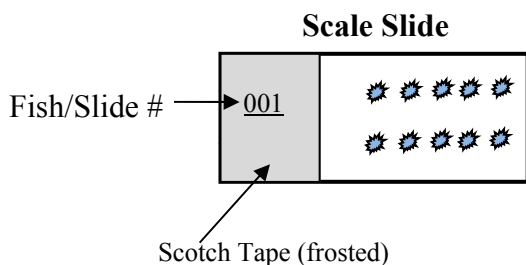
Location:_Cowee__   Date:_____

Species:_Coho_____   Sample #_____

Length:_____   Scale determined Age:_____

Date	Fish/Slide #	Length (mm)	Weight (g)	Age	Comments

Appendix D6.–Data form used to record age, sex, and length data collected during adult coho escapement surveys.

Cowee Creek Adult Coho ASL Data Form

Pg _____ of _____

Location (circle one):   lower Cowee   upper Cowee   Davies Creek

Date pg. started: _____

Crew: _____

Date pg. ended: _____

Weather comments: _____

Water conditions: _____

Sample Date	Wpt/ Error	Cum Fish #	Gear* (T/B/Sp/Sn)	Sex (M/F)	Scale Card #	Scale # (1-10)	Length (MEF) (mm)	Age (FW)	Age (SW)	AEC	Anchor Tag #	Cinch # (ad clip)	Operc Punch	Cond** (1-5)	Comments (unmarked?, recap?, anchor tag #, operc punch, sea lice, etc.)

(Age (FW), Age (SW), AEC = Office Use Only)

*Gear: **T** = tangle net   **B** = beach seine   **Sp** = sport   **Sn** = snag

**Condition:
- **1** = bright
- **2** = slight coloration
- **3** = obvious coloration, pre-spawn
- **4** = post-spawn
- **5** = carcass

Operculum Punches			
8/3-8/9	RU	9/7-9/13	LLL
8/10-8/16	RM	9/14-9/20	RUU
8/17-8/23	RU	9/21-9/27	RLL
8/24-8/30	RL	9/28-10/4	LUL
8/31-9/6	LUU	10/5-10/11	RUL
Event 2 – LL only			

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Appendix D7.–The ADF&G Southeast Region Rack Return and Escapement Survey Form used to record data associated with fish heads sent to the Mark, Tag, and Age Laboratory for coded wire tag recovery.

Alaska Department of Fish and Game
Coded Wire Tag Sampling Form
Rack Return and Escapement Survey
Southeast Region

PAGE [ ] OF PAGES [ ]

Page info for this Sample Number only/ See instructions

SAMPLE NUMBER: 1 [ ][ ][ ][ ][ ][ ]

SOURCE: (circle one)   rack return   escapement survey

SURVEY SITE: _____

SAMPLE TYPE: random   select

SAMPLER: _____

DATE SAMPLED: [ ][ ] - [ ][ ] - 1[ ]

SAMPLING INFORMATION

This Box to be completed for RANDOM Samples Only

SPECIES (CODE)	TOTAL # FISH CHECKED FOR AD-CLIPS	# AD-CLIPS SEEN	WERE ALL CHECKED?
(410)CHIN	_____	_____	y n
(411)JACK CHINOOK-ONLY	_____	_____	y n
(420)SOCK	_____	_____	y n
(430)COHO	_____	_____	y n
(440)PINK Not in S.E.	_____	_____	y n
(450)CHUM	_____	_____	y n
(540)STHD	_____	_____	y n

COMMENTS

AREA INFORMATION (DISTRICT – SUBDISTRICT)

101-	106-	111-	116-	157-	191-
102-	107-	112-	150-	181-	192-
103-	108-	113-	152-	182-	OTHER DISTRICTS
104-	109-	114-	154-	183-	_____
105-	110-	115-	156-	189-	_____

NAME of PLACE SURVEYED: (HATCHERY OR STREAM) _____

WATER TYPE: saltwater   freshwater

ANADROMOUS STREAM# (FRESHWATER-ONLY) ___ - ___ - ___ - ___

HEAD RECOVERY INFORMATION

✓	HEAD NUMBER	SPECIES CODE	LENGTH (mid-eye to fork in mm)	CLIP	SEX

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Appendix D8.–Data form used to record daily environmental conditions.

Cowee Creek Environmental Conditions Data Form

Date/time	Air temp (°C)	Water temp (°C)	Staff Gage (dec. ft.)	Water Clarity (clear vs. turbid)	Weather* (C, O, R, S, W)	Comments (water level rising/falling, rain on snow event, high water, low water, etc.)

*Weather: **C** = clear

                    O = overcast

                    R = raining

                    S = snowing

W = windy

APPENDIX E: STATISTICAL TESTS FOR ANALYZING DATA FOR SEX AND SIZE BIAS AND TEMPORAL/GEOGRAPHIC VARIATION IN CAPTURE PROBABILITIES

Appendix E9.–Detection of size and/or sex selective sampling during a 2-sample mark recapture experiment and its effects on estimation of population size and population composition.

Size selective sampling: The Kolmogorov-Smirnov 2 sample test (Conover 1980) is used to detect significant evidence that size selective sampling occurred during the first and/or second sampling events. The second sampling event is evaluated by comparing the length frequency distribution of all fish marked during the first event (M) with that of marked fish recaptured during the second event (R) by using the null test hypothesis of no difference. The first sampling event is evaluated by comparing the length frequency distribution of all fish inspected for marks during the second event (C) with that of R. A third test that compares M and C is then conducted and used to evaluate the results of the first 2 tests when sample sizes are small. Guidelines for small sample sizes are <30 for R and <100 for M or C.

Sex selective sampling: Contingency table analysis (Chi^2-test) is generally used to detect significant evidence that sex selective sampling occurred during the first and/or second sampling events. The counts of observed males to females are compared between M&R, C&R, and M&C using the null hypothesis that the probability that a sampled fish is male or female is independent of sample. If the proportions by gender are estimated for a sample (usually C), rather an observed for all fish in the sample, contingency table analysis is not appropriate and the proportions of females (or males) are then compared between samples using a 2 sample test (e.g. Student's t-test).

M vs. R	C vs. R	M vs. C

Case I:

Fail to reject H_o	Fail to reject H_o	Fail to reject H_o

There is no size/sex selectivity detected during either sampling event.

Case II:

Reject H_o	Fail to reject H_o	Reject H_o

There is no size/sex selectivity detected during the first event but there is during the second event sampling.

Case III:

Fail to reject H_o	Reject H_o	Reject H_o

There is no size/sex selectivity detected during the second event but there is during the first event sampling.

Case IV:

Reject H_o	Reject H_o	Either result possible

There is size/sex selectivity detected during both the first and second sampling events.

Evaluation Required:

Fail to reject H_o	Fail to reject H_o	Reject H_o

Sample sizes and powers of tests must be considered:

A. If sample sizes for M vs. R and C vs. R tests are not small and sample sizes for M vs. C test are very large, the M vs. C test is likely detecting small differences which have little potential to result in bias during estimation. *Case I* is appropriate.

B. If a) sample sizes for M vs. R are small, b) the M vs. R p-value is not large (~0.20 or less), and c) the C vs. R sample sizes are not small and/or the C vs. R p-value is fairly large (~0.30 or more), the rejection of the null in the M vs. C test was likely the result of size/sex selectivity during the second event which the M vs. R test was not powerful enough to detect. *Case I* may be considered but *Case II* is the recommended, conservative interpretation.

C. If a) sample sizes for C vs. R are small, b) the C vs. R p-value is not large (~0.20 or less), and c) the M vs. R sample sizes are not small and/or the M vs. R p-value is fairly large (~0.30 or more), the rejection of the null in the M vs. C test was likely the result of size/sex selectivity during the first event which the C vs. R test was not powerful enough to detect. *Case I* may be considered but *Case III* is the recommended, conservative interpretation.

D. If a) sample sizes for C vs. R and M vs. R are both small, and b) both the C vs. R and M vs. R p-values are not large (~0.20 or less), the rejection of the null in the M vs. C test may be the result of size/sex selectivity during both events which the C vs. R and M vs. R tests were not powerful enough to detect. *Cases I, II, or III* may be considered but *Case IV* is the recommended, conservative interpretation.

Case I. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated after pooling length, sex, and age data from both sampling events.

Case II. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated using length, sex, and age data from the first sampling event without stratification. If composition is estimated from second event data or after pooling both sampling events, data must first be stratified to eliminate variability in capture probability (detected by the M vs. R test) within strata. Composition parameters are estimated within strata, and abundance for each stratum needs to be estimated using a Petersen-type formula. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance according to the formulae below.

Case III. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated using length, sex, and age data from the second sampling event without stratification. If composition is estimated from first event data or after pooling both sampling events, data must first be stratified to eliminate variability in capture probability (detected by the C vs. R test) within strata. Composition parameters are estimated within strata, and abundance for each stratum needs to be estimated using a Petersen-type type formula. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance according to the formulae below.

Case IV. Data must be stratified to eliminate variability in capture probability within strata for at least one or both sampling events. Abundance is calculated using a Petersen-type model for each stratum, and estimates are summed across strata to estimate overall abundance. Composition parameters may be estimated within the strata as determined above, but only using data from sampling events where stratification has eliminated variability in capture probabilities within strata. If data from both sampling events are to be used, further stratification may be necessary to meet the condition of capture homogeneity within strata for both events. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance.

If stratification by sex or length is necessary prior to estimating composition parameters, then an overall composition parameters (p_k) is estimated by combining within stratum composition estimates using:

$$\hat{p}_k = \sum_{i=1}^{j} \frac{\hat{N}_i}{\hat{N}_\Sigma} \hat{p}_{ik} \text{ ; and,} \tag{1}$$

$$\hat{V}[\hat{p}_k] \approx \frac{1}{\hat{N}_\Sigma^2} \sum_{i=1}^{j} \left(\hat{N}_i^2 \hat{V}[\hat{p}_{ik}] + \left(\hat{p}_{ik} - \hat{p}_k \right)^2 \hat{V}[\hat{N}_i] \right). \tag{2}$$

where: j =   the number of sex/size strata;
          $\hat{p}_{ik}$ =   the estimated proportion of fish that were age or size k among fish in stratum i;
          $\hat{N}_i$ =   the estimated abundance in stratum i; and,
          $\hat{N}_\Sigma$ =   sum of the $\hat{N}_i$ across strata.

Appendix E10.–Tests of consistency for the Petersen estimator (from Seber 1982, page 438).

TESTS OF CONSISTENCY FOR PETERSEN ESTIMATOR

Of the following conditions, at least one must be fulfilled to meet assumptions of a Petersen estimator:

1. Marked fish mix completely with unmarked fish between events;
2. Every fish has an equal probability of being captured and marked during Event 1; or,
3. Every fish has an equal probability of being captured and examined during Event 2.

To evaluate these 3 assumptions, the chi-square statistic will be used to examine the following contingency tables as recommended by Seber (1982). At least one null hypothesis needs to be accepted for assumptions of the Petersen model (Bailey 1951, 1952; Chapman 1951) to be valid. If all 3 tests are rejected, a temporally or geographically stratified estimator (Darroch 1961) should be used to estimate abundance.

I.-Test For Complete Mixing[a]

Area/Time Where Marked	Area/Time Where Recaptured				Not Recaptured (n_1-m_2)
	1	**2**	**…**	**t**	
1					
2					
…					
s					

II.-Test For Equal Probability of capture during the first event[b]

	Area/Time Where Examined			
	1	**2**	**…**	**t**
Marked (m_2)				
Unmarked (n_2-m_2)				

III.-Test for equal probability of capture during the second event[c]

	Area/Time Where Marked			
	1	**2**	**…**	**s**
Recaptured (m_2)				
Not Recaptured (n_1-m_2)				

[a] This tests the hypothesis that movement probabilities (θ) from time or area i (i = 1, 2, ...s) to section j (j = 1, 2, ...t) are the same among sections: H_0: $\theta_{ij} = \theta_j$.

[b] This tests the hypothesis of homogeneity on the columns of the 2-by-t contingency table with respect to the marked-to-unmarked ratio among time or area designations: H_0: $\Sigma_i a_i \theta_{ij} = kU_j$, where k = total marks released/total unmarked in the population, U_j = total unmarked fish in stratum j at the time of sampling, and a_i = number of marked fish released in stratum i.

[c] This tests the hypothesis of homogeneity on the columns of this 2-by-s contingency table with respect to recapture probabilities among time or area designations: H_0: $\Sigma_j \theta_{ij} p_j = d$, where p_j is the probability of capturing a fish in section j during the second event, and d is a constant.